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September 1997

Effects of Water Diversion on Freshwater Mussels in the Pearl River Near Walkiah Bluff, Mississippi and Louisiana, 1995

by Andrew C. Miller, Barry S. Payne

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Final report

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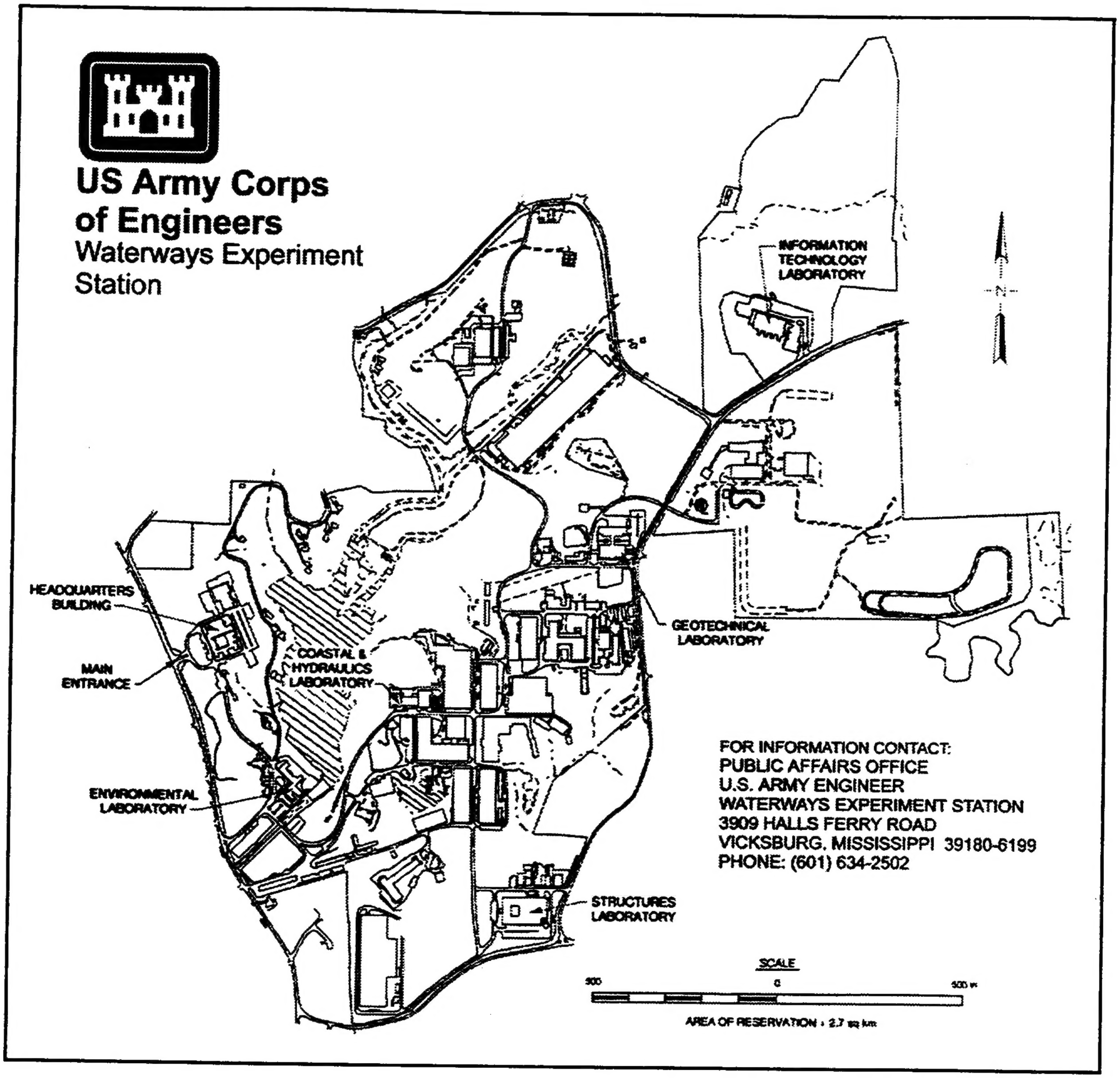

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Preface

A survey to assess community characteristics, density, population demography of dominant species, and the presence of endangered species of mussels (family: Unionidae) was conducted in the Pearl River near Picayune, MS. Work was done for the U.S. Army Engineer District, Vicksburg, and results are being used to assess the environmental effects of three proposed water-diversion alternatives designed to increase water flow in the Pearl River near Walkiah Bluff, Mississippi and Louisiana. Studies were conducted by the U.S. Army Engineer Waterways Experiment Station (WES) in August-October 1995.

Divers were Messrs. Larry Neill, Robert T. James, Robert Warden, and Johnny Buchanan from the Tennessee Valley Authority (TVA). Assistance in the field was provided by Mr. David Morrow, Ms. Nancy Atwood, Mr. David Armistead, and Mr. Steven George, all from WES. Mr. Gary Young, U.S. Army Engineer District, Vicksburg, assisted with the design of the survey and provided maps and other background information. Figures were prepared by Ms. Geralline Wilkerson, Jackson State University.

During the conduct of this study, Dr. John W. Keeley was Director, Environmental Laboratory (EL), WES; Dr. Conrad J. Kirby was Chief, Environmental Resources Division (ERD), EL; and Dr. Alfred F. Cofrancesco was Chief, Aquatic Habitat Group (AHG), ERD. Air boats and selected field gear were provided by divers from TVA. Authors of this report were Drs. Andrew C. Miller and Barry S. Payne, AHG.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
inches	2.54	centimeters
miles	1.852	kilometers

1 Introduction

Background

Project description

The U.S. Army Engineer District, Vicksburg, proposes to restore dependable low flow in a reach of the Pearl River near Walkiah Bluff, Mississippi and Louisiana. Over the past few years, water has declined in this reach because of a gradual widening of various sloughs and channels, especially Wilson Slough, which drains in a westerly direction toward the Pearl River Canal. Three alternatives to redistribute low flows are being formulated and evaluated. Adding water to this reach of the Pearl River will have ecological, recreational, and economic effects. Conversely, some negative effects could be caused by reducing flow through Wilson Slough. Project construction, which will involve some pilot channel excavation, could have negative effects.

Results of recent surveys by personnel of the U.S. Army Engineer Waterways Experiment Station (WES) indicated that extensive beds of freshwater mussels exist in the Pearl River. Personnel of the Vicksburg District requested that a mussel survey be conducted in river reaches that would be directly and indirectly affected by plans to redistribute flow. Specific attention would be directed toward the threatened heelsplitter mussel, *Potamilus inflatus*.

Freshwater mussels

Freshwater mussels (family: Unionidae) dominate the benthic biomass of stable gravel shoals in medium-sized to large rivers in the central United States. They are virtually nonmotile, live 20 or more years, and feed by filtering particulate organic matter from the water. Eggs are brooded in the gills, and immature mussels once released from the female spend a brief period on the fins or gills of a host fish (Coker 1919; Fuller 1974). Before the advent of plastics, shells were used in the button industry; today they are used to culture pearls (Sweaney and Latendresse 1982; Sitwell 1985). Most thick-shelled species are tolerant of days or weeks of desiccation and can close their valves to avoid short periods of anoxia or poor water quality. Once large-river species reach adult size, their thick shells make them invulnerable to most

predators. Regardless of their ability to tolerate natural and man-made disturbances, many species are considered to be imperiled (See Williams et al. 1993). Since the late 1970s the Unionidae have received considerable legislative protection from local, State, and Federal agencies (U.S Fish and Wildlife Service 1994).

Freshwater mussels are usually found where water velocities vary from 0.5 to 1.5 ft/sec.[1] Occasionally, thin-shelled mussels such as the paper pondshell, *Utterbackia imbecillis*, or the thick-shelled threeridge, *Amblema p. plicata*, reach densities of 200 to 300 individuals/square meter in water flowing less than 0.5 ft/sec. However, these cases are relatively uncommon. Mussels can be found in water flowing faster than 2.0 ft/sec, although usually they are not abundant.

Purpose and Scope

The purpose of this study is to survey reaches of the Pearl River near Picayune, MS, for freshwater mussels. Data will be used as a part of a study on effects of altering flow in the Pearl River near Walkiah Bluff.

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[1] A table of factors for converting non-SI units of measurement to SI units is presented on page viii.

2 Study Area and Methods

Study Area

The study area includes sections of the Pearl River, Holmes Bayou, Wilson Slough, and the West Pearl River near Picayune, MS, on the extreme southwestern tip of Mississippi, near the Louisiana border (Figure 1). Results of this survey have been organized by river reaches delineated by the Vicksburg District (see Figure 2). The following describes conditions in each river reach.

Reach 1—Pearl River from mouth of Wilson Slough downriver to exit point of Ice Box Slough, near Walkiah Bluff

Substratum in this reach consisted of sand and gravel with exposed shoals with water depths between 1 and 3 ft during low flow. Substratum in the section downriver of the exit of Moore's Bayou consisted mainly of fine-grained sands and silt with little or no gravel.

Reach 2—Between exit of Ice Box Slough downriver to point where the slough re-enters Pearl River

This reach was shallow, less than 2 to 3 ft during low flow. Substratum consisted of sand, gravel, and silt. Log jams and fallen timber were common. Reaches 1 and 2 were shallow, water velocity was low, and substratum was stable.

Reach 3—Pearl River from Ice Box Slough downriver to Farr Slough

Substratum in this reach consisted mainly of gravel and sand. Water was shallow at low flow, usually less than 2 to 3 ft, although in some pools depths were 6 or more ft.

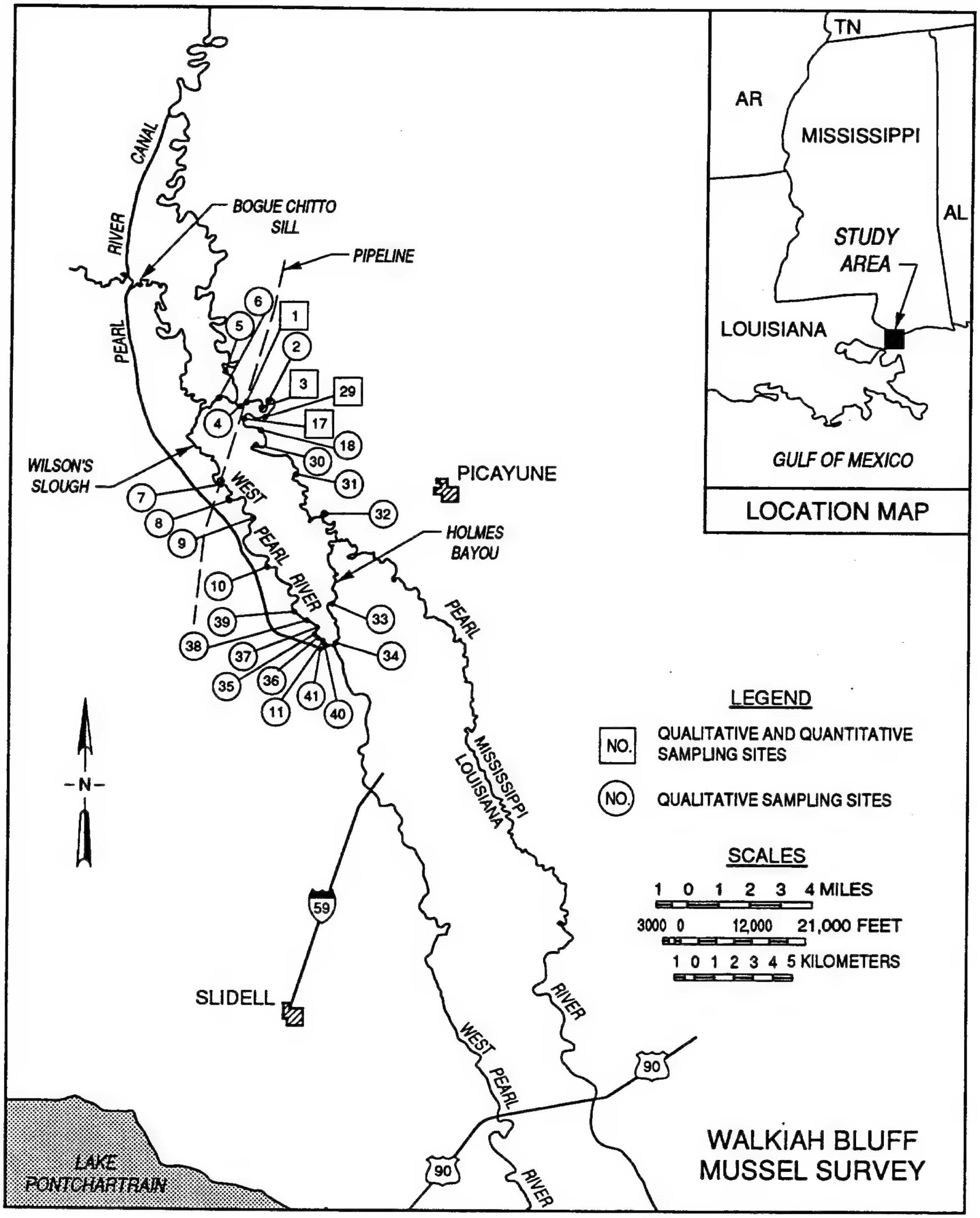

Figure 1. Sites surveyed for mussels using quantitative and qualitative methods, Pearl and West Pearl rivers, 1995 (see Table 1)

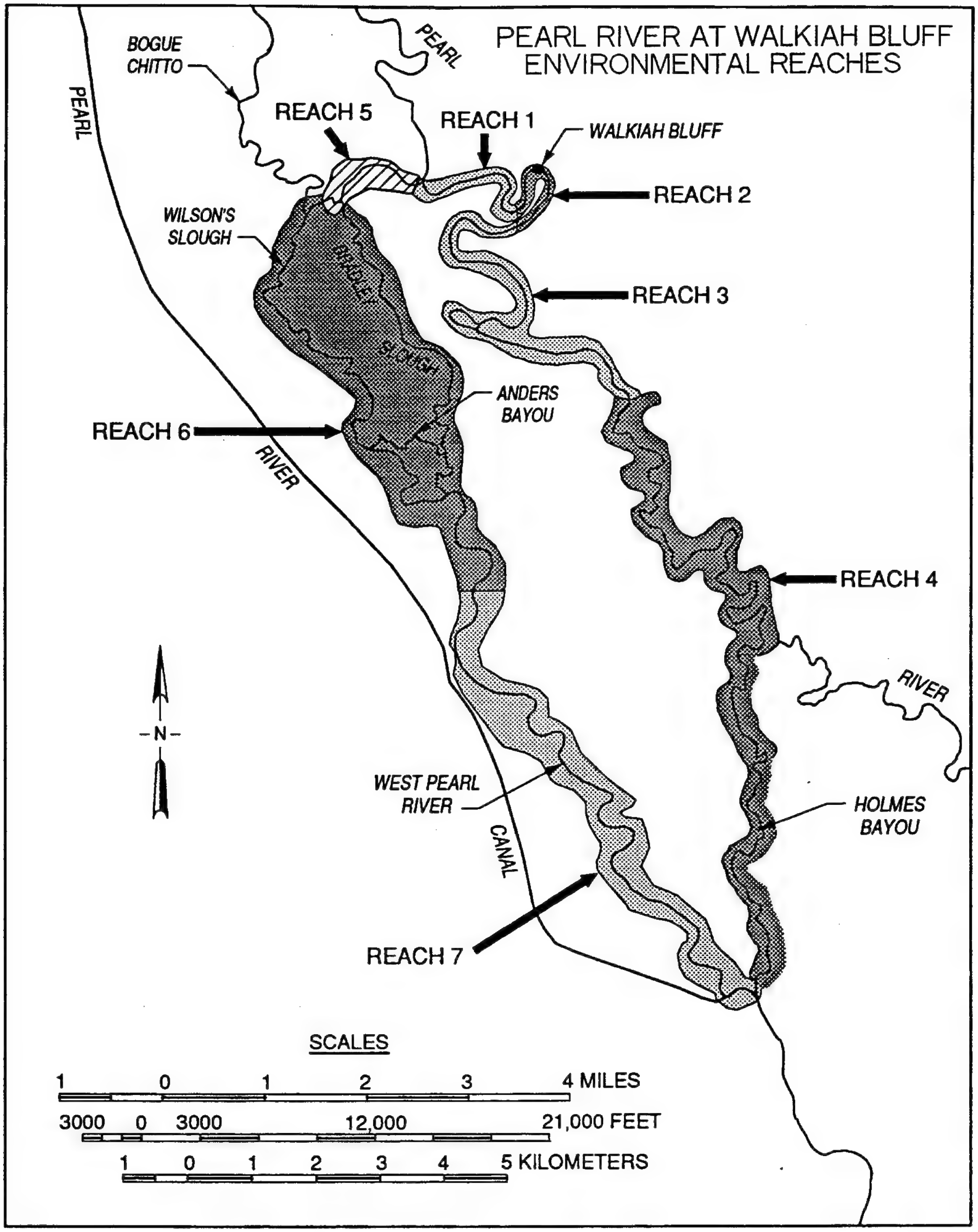

Figure 2. River reaches of study area where mussels were collected (see Table 1)

Reach 4—Holmes Slough from Farr Slough downriver to West Pearl River near downriver end of Lateral Canal

Water depths were 4 to 6 ft in pools and runs in this reach. Substratum consisted mainly of sand, or sand and gravel.

Reach 5—Upriver portion of Wilson Slough downriver to a reach just upriver of mouth of Bogue Chitto River

High-velocity water (1 to 2 ft/sec) characterized this reach. Substratum consisted mainly of sand and gravelly sand. Water depths during low flow were usually 4 to 6 ft deep with occasionally deeper water.

Reach 6—Wilson Slough from Reach 5 downriver to a location near Becky Lake

Flow in this reach was augmented by water from the Bogue Chitto River. Depths at low flow were 6 to 8 ft in the channel. Substratum consisted of sand and gravelly sand.

Reach 7—Extends from lower end of Reach 6 to mouth of Holmes Bayou near end of Lateral canal

Substratum consisted of gravelly sand with many exposed sandy shoals. Water depths at low flow were usually 6 ft or deeper. Reaches 5-7 had moderate- to high-velocity water with relatively unstable substratum.

All seven reaches were searched for live mussels. Quantitative samples were taken in Reaches 1, 2, and 3 only. Lower densities in Reaches 4-7 made qualitative sampling more efficient. No mussels were found in Reach 5, although mussels were found upriver of the cutoff to Wilson Slough. A listing of all sample sites is in Table 1.

Methods

Preliminary reconnaissance

A preliminary reconnaissance of the study area was conducted prior to initiating intensive sampling. This was accomplished by two individuals who traversed the area in a small boat and inspected the shore and shallow water for live mussels and dead shells. They obtained information on substratum conditions, water velocity, and presence of instream cover. Field notes were recorded, and sites requiring detailed study were marked on topographic

Table 1
Sample Sites

Date	Site No.	Reach	No. of Samples		Description
			Quantitative	Qualitative	
21 Aug	1	1	30	32	Head of Moore's Bayou
22 Aug	3	1	15	4	Near Walkiah Bluff
22 Aug	4	1	--	6	Between Head of Moore's Bayou and Wilson Slough
22 Aug	2	2	--	8	Near Walkiah Bluff
27 Sep	29	2	10	14	Downriver of end of Ice Box Slough
24 Sep	17	3	15	37	Downriver of end of Moore's Bayou
24 Sep	18	3	--	6	Near Stewart's Bluff
27 Sep	30	3	--	8	Near Nances Lake
27 Sep	31	4	--	8	Near Farr Slough
27 Sep	32	4	--	2	Near Gum Landing
27 Sep	33	4	--	2	Mouth of Little Holmes Bayou
27 Sep	34	4	--	2	Mouth of Holmes Bayou
22 Aug	5	NA	--	6	Upriver of Cutoff to Wilson Slough and upriver of Reach 5
22 Aug	6	6	--	1	Upper part of Wilson Slough

(Continued)

Table 1 (Concluded)

Date	Site No.	Reach	No. of Samples		Description
			Quantitative	Qualitative	
23 Aug	7	6	--	0	Between Pipeline Crossing and L Canal
23 Aug	8	6	--	1	Between Pipeline Crossing and L Canal
23 Aug	9	6	--	2	Between Pipeline Crossing and L Canal
23 Aug	10	7	--	1	Between Pipeline Crossing and L Canal
23 Aug	11	7	--	3	Between Pipeline Crossing and L Canal
28 Sep	35	7	--	2	Between Pipeline Crossing and L Canal
28 Sep	36	7	--	2	Between Pipeline Crossing and L Canal
28 Sep	37	7	--	2	Between Pipeline Crossing and L Canal
28 Sep	38	7	--	1	Between Pipeline Crossing and L Canal
28 Sep	39	7	--	2	Between Pipeline Crossing and L Canal
28 Sep	40	7	--	2	Between Pipeline Crossing and L Canal
Oct	41	7	--	1	Lateral Canal at West Pearl

maps. Sites with a high likelihood of finding mussels were usually depositional areas, natural constrictions, or sharp bends.

Qualitative and quantitative sampling was accomplished by divers in water deeper than 1 m and by waders in shallow water. Divers and waders used the same collecting methods.

Qualitative mussel samples

Qualitative samples were obtained by having each collector place a specific number of live mussels in nylon bags, usually 5 to 20. Collections were made without bias toward size or type. Workers attempted to exclude the Asiatic clam, *Corbicula fluminea*. If this species was inadvertently collected, it was later eliminated. The total time spent searching was recorded so that the number of mussels collected per minute could be determined.

Special attention was directed toward locating live specimens or shells of the threatened heelsplitter mussel, *P. inflatus*. An intensive search for this species was made at exposed sand and gravel bars in Reaches 5-7 (Figure 3).

All mussels were brought to the surface, counted, and identified. Data were recorded on standard data sheets and returned to the laboratory for analysis and plotting. Shells of voucher specimens for each species were placed in plastic zipper-lock bags and labeled with high rag content paper. Mussels not needed for voucher were returned to the river. Methods for sampling mussels are based on techniques described in Miller and Nelson (1983); Isom and Gooch (1986); Kovalak, Dennis, and Bates (1986); Miller and Payne (1988); and Miller et al. 1994. Mussel identification was based on taxonomic keys and descriptive information in Murray and Leonard (1962), Parmalee (1967), Starrett (1971), and Burch (1975). Taxonomy is consistent with Williams et al. (1993).

Quantitative mussel samples

In addition to qualitative samples, quantitative samples (that included unionids as well as *C. fluminea*) were obtained at moderate- to high-density sites (at least 10 to 20 individuals/square meter). Quantitative samples were taken with 0.25-sq m quadrats; usually 10 or more were taken at each site. All sand, gravel, shells, and live bivalves to a depth of 10 to 15 cm were excavated. Material was sent to the surface in a 20-ℓ bucket and transported to shore. Sediment was screened through three screens (with mesh sizes of 6.35, 12.7, and 34.0 mm). All live mussels (including *C. fluminea)* removed from samples were placed in 4-ℓ zipper-lock bags. Each bivalve was then identified and total shell length (SL) measured to the nearest 0.1 mm with digital calipers. Mussels identified and measured in the field were returned to the river unharmed.

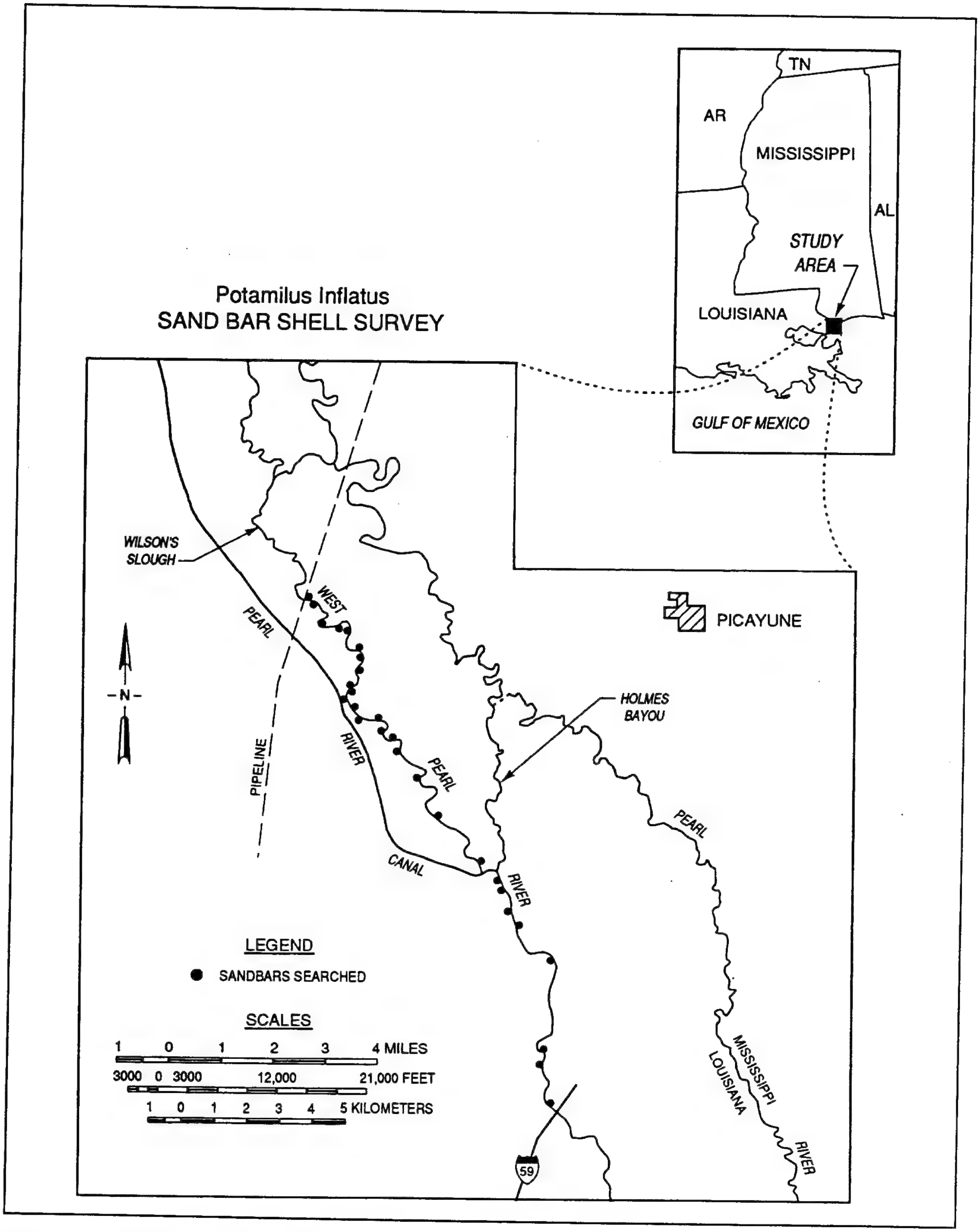

Figure 3. Sand bars specifically searched for *P. inflatus* in Reaches 6 and 7

Analysis of mussel data

Species diversity was determined with the following formula:

$$H' = - p_j \log p_j$$

where p_j is the proportion of the population that is of the j^{th} species (Shannon and Weaver 1949). Evenness was calculated with the modified Hill's ratio (Ludwig and Reynolds 1988). All calculations were done with programs written in BASIC or SAS (Statistical Analytical System) on a personal computer. Species area curves and dominance-diversity curves were constructed from qualitative and quantitative biological data.

Determination of habitat suitability values

In the field, measurements of water velocity, substratum stability, and grain-size distribution were made. These data were used to calculate Habitat Suitability Index (HSI) values, which are used in the Habitat Evaluation Procedures (U.S. Fish and Wildlife Service 1981). The HSI values were obtained from community models derived for gravel bar habitats reported by Miller et al. (1987).

3 Bivalve Community

Characterization of Bivalve Community

A total of 29 species of bivalves, including the nonindigenous *C. fluminea*, was collected in the Pearl and West Pearl rivers (Table 2). Twenty-seven species were collected using qualitative methods, and 15 species were collected using quantitative methods. The nonindigenous zebra mussel, *Dreissena polymorpha*, introduced into the Great Lakes in the late 1980s, was not found. Qualitative collecting, because more individuals were collected and more sites were surveyed, yielded more species than the quantitative sampling. However, the quantitative sampling provides information on density and evidence of recent recruitment that cannot be obtained from qualitative sampling.

The bivalve community in the project area can be characterized as species rich and diverse; no single species dominated (Appendixes A and B). Typically, mussel beds were dominated by three to five species that comprised 10 to 40 percent of the community. Commonly collected species were *Quadrula refulgens*, *Obliquaria reflexa*, *Quadrula apiculata*, and *Truncilla donaciformis*. Evidence of recent recruitment was high; as many as 71 percent of the individuals at a site were less than 30 mm total SL (Site 1, Subsite 3, see Appendix A, Table A1). Communities were dominated by relatively small-sized mussels with thick to moderately thick shells. Thin-shelled species (*Leptodea fragilis*, *Pyganodon* spp., and *Utterbackia* sp.) were uncommon or absent at most sites. Species belonging to the genus *Utterbackia* and *Pyganodon* are usually found in fine-grained sediments in low-velocity water. These thin-shelled species have no commercial value. Species favored by the commercial shellers (*M. nervosa*, *A. p. plicata*, and large species of *Quadrula*) were either very uncommon or not present in the study area.

Table 2
Freshwater Bivalves Collected Using Qualitative and Quantitative Methods in the Pearl and West Pearl Rivers, 1995

Species	Qualitative	Quantitative
Amblema p. plicata (Say)	X	
Corbicula fluminea (Muller)	X	X
Elliptio crassidens (Lamarck)	X	
Fusconaia ebena (I. Lea)	X	X
Fusconaia cerina (Conrad)	X	
Glebula rotundata (Lamarck)	X	X
Lampsilis clairbornensis	X	
Lampsilis ornata (Conrad)	X	
Lampsilis teres (Rafinesque)	X	
Ligumia subrostrata (Say)	X	
Leptodea fragilis (Rafinesque)	X	X
Obliquaria reflexa (Rafinesque)	X	X
Obovaria unicolor (I. Lea)	X	
Plectomerus dombeyanus (Valenciennes)	X	X
Pleurobema pyramidatum (I. Lea)	X	
Potamilus alatus (Say)	X	
Potamilus pupuratus (Lamarck)	X	X
Pyganodon grandis (Say)	X	
Quadrula apiculata (Say)	X	X
Quadrula quadrula (Rafinesque)	X	X
Quadrula refulgens (I. Lea)	X	X
Quadrula rumphiana (I. Lea)		X
Toxolasma texasensis (I. Lea)	X	
Tritogonia verrucosa (Rafinesque)	X	
Truncilla donaciformis (I. Lea)	X	X
Truncilla truncata Rafinesque	X	
Uniomerus declivis (Say)	X	X
Uniomerus tetralasmus (Say)		X
Utterbackia imbecillis Say	X	X
Villosa lienosa (Conrad)	X	
Total species	28	15

Description of Bivalves in Each River Reach

Reach 1

Aquatic habitat in Reach 1 was excellent for mussels. During the study period, water depths were usually less than 6 ft, and current velocity was usually less than 3 ft/sec, which provided stable conditions for mussels. At a stable gravel bar near the mouth of Moore's Bayou, densities at three subsites (10 samples were collected at each) were 98.0, 3.2, and 34.0 (Table A8). Evidence of recent recruitment was good; the percentage of mussels less than 30 mm total SL (typically 1 to 2 years old) were 17, 12, and 72 percent (Table A1). Overall, more than 50 percent of the species had a least one individual less than 30 mm total SL. *Quadrula refulgens, O. reflexa,* and *Q. apiculata* were most abundant and comprised 39, 30, and 17 percent of the fauna. Species diversity, a measure of the number of species and their distribution within the community, was moderately high, 1.54 for all three subsites combined.

Substratum at Site 3 consisted of fine-grained material with little gravel present. Mean mussel density was 6.4, 4.0, and 132 individuals/square meter on the right descending bank (RDB), center, and left descending bank (LDB), respectively. As with Site 1, species diversity was high (2.02 at the high-density site) and mussels were evenly distributed within the community. No species strongly dominated, as is often the case in stressed habitats or areas with low substratum diversity. Evidence of recent recruitment was good; 29 percent of all individuals and 57 percent of all species were less than 30 mm total SL. Species indicative of fine-grained substratum such as *Plectomerus dombeyanus*, *Potamilus purpuratus*, *U. imbecillis*, and *Anodonta suborbiculata* were fairly common. Mussels in this reach had virtually no commercial value; neither the threeridge (*Amblema p. plicata*) or the washboard *M. nervosa*) were present.

Based upon qualitative sampling, a total of 19 species were found in a collection of 754 individuals (Table 3). Mussels were collected at a rate of 7.54 per minute. Based upon densities, number of species collected, and species diversity, this reach was considered excellent for mussels.

Reach 2

During the study period, Reach 2 was impassable by boat because of exposed sand gravel bars and fallen logs. Conditions for mussels were good; 1,281 individuals were collected and 25 species were identified. Collection rate was 5.6 individuals/minute (Table 3).

At a study site near the point where Ice Box Slough re-enters the Pearl River, five quantitative samples were taken along the LDB, and five were taken in the channel. No mussels were found in the channel, although

Table 3
Summary of Conditions for Mussels and Results of Qualitative Mussel Collections in the Seven River Reaches of the Pearl and West Pearl Rivers for the Walkiah Bluff Water-Diversion Project

River Reach	*P. inflatus* Present?	No. of Species	No. of Individuals	Total Time	Rate Mussels/min	Overall Conditions for Mussels	Effects of Water Diversion
1	No	19	754	100	7.54	Stable sand-gravel substratum	Benefits of increased water level
2	No	25	1,281	230	5.57	Silt and stable, sand-gravel substratum	Benefits of increased water level
3	No	19	683	300	2.28	Stable sand-gravel substratum	Minor benefits of increased flow
4	No	14	167	300	0.56	Moderate velocity, few gravel bars	Little or no effect (positive or negative)
5	No	13	0	0	0.00	High velocity, erosive area	Minor benefit of decreased velocity
6	Yes	16	32	130	0.25	Moderate velocity, sand-gravel bars present	Little or no effect (positive or negative)
7	Yes	19	938	710	1.32	Moderate velocity, sand-gravel bars present	Little or no effect (positive or negative)

densities along the bank were moderate—34.4 individuals/square meter. Densities of *C. fluminea* were high; 1,620.8/square meter were found along in the channel, and 82.4/square meter were found along the LDB.

Recruitment of native mussels was good; 40 percent of the individuals and 25 percent of the species had at least one individual less than 30 mm total SL. Species diversity was high (2.15); *T. donaciformis*, *Q. refulgens*, and *L. fragilis* were most abundant and comprised 28, 19, and 12 percent, respectively, of the community.

Reach 3

Using qualitative methods, 167 individuals were collected, and 14 species were identified in Reach 3. Collection rate was less than half that of Reach 1 or 2, 2.3 individuals/minute (Table 3).

At a stable shoal near the point where Moore's Bayou enters the river densities along the LDB, midchannel, and RDB were 92.8, 117.6, and 60.0 individuals/square meter. Mean densities of *C. fluminea* were 37.6, 44.8, and 130.4 individuals along the LDB, midchannel, and RDB. *Quadrula refulgens* dominated (47 percent), which was more than twice as abundant as the next two abundant species, *T. donaciformis* and *O. reflexa*. A thin-shelled species (*U. imbecillis*) and a mussel usually found along muddy banks (*P. dombeyanus*) were common.

Reach 4

A total of 14 species and 167 individuals were collected in Reach 4. Total time expended collecting was 300 min for a rate of 0.56 individuals/minute (Table 3). *Potamilus purpuratus* and *P. dombeyanus*, both found in fine-grained substratum, were common. Substratum in this reach consisted mainly of sand, with little gravel, and was not very suitable for mussels.

Reach 5

Several sites were searched in Reach 5, but no live mussels were collected. There were no exposed bars in this reach where shells or live mussels were likely to be found.

Reaches 6 and 7

Sixteen and nineteen species were collected in Reaches 6 and 7, respectively (Table 3). Live mussels were found along the shore and near exposed gravel bars. The collection rate was 0.25 individuals/minute in Reach 6 and 1.32 individuals/minute in Reach 7.

Five shells of *P. inflatus* were collected in these two reaches; most were located in the lower section of Reach 7 near the lateral canal. Specimens were in good condition, which indicates that they had been dead less than a year. Because these shells are extremely thin, it is likely that they would be destroyed by a period of high water. Most shells were nearly adult size and 5 or more years old. One was about 60 mm long and was probably less than 5 years old. No live specimens were collected. However, there is no doubt that live *P. inflatus* exist in this river reach.

Size Demography of Dominant Mussels

In Reaches 1 and 3, a sufficient number of mussels were obtained to analyze the population size structure of several of the more abundant species (see figures in Appendix C). In both reaches, population size structure suggested a healthy mussel resource, as populations included both large and small mussels. Such size structure indicates good recruitment and survivorship.

The population of *Q. apiculata* at Site 1 in Reach 1 provides an excellent example of size structure indicative of a healthy assemblage. Small, recent recruits (mussels 16 to 28 mm long) were moderately abundant, comprising 25 percent of the population. Mussels ranging up to 76 mm long comprised the remainder of the population and included individuals representing most possible size and age classes. Demography of *Q. apiculata* at Sites 2 and 3 (Reach 1) and at Site 17 (Reach 3) was essentially the same as at Site 1 (Reach 1).

Similar diversity of size and age structure within populations was apparent for *O. reflexa*, *Q. refulgens*, *T. donaciformis*, *Glebula rotundata*, *L. fragilis*, *P. dombeyanus*, *P. purpuratus*, and *Tritogonia verrucosa*. Thus, moderately strong recruitment and survival to relatively large size and old age characterizes the mussel community in the Pearl River.

Concluding Comments on Nonthreatened Mussel Species

Total species richness in the project area (29) is greater than that found in most medium-sized to large rivers in the central United States. At a gravel bar in the lower Ohio River near Olmsted, IL, 23 species of mussels were identified. In a survey of a gravel bar in the lower Tennessee River, 4,768 individuals were collected and 23 species were identified (Miller, Payne, and Tippit 1992). In the east channel of the upper Mississippi River near Prairie du Chien, WI (River Mile (RM) 635), 30 species were identified (Miller and Payne 1993a).

The unionid fauna of most large-river mussel beds is dominated by two or three species. Based on quantitative sampling, the bed at Site 1 (Reach 1) was

dominated by three species, *Q. refulgens* (39 percent), *O. reflexa* (29.6 percent), and *Q. apiculata* (16.6 percent). Community composition was similar to a bed in the middle Ohio River near Cincinnati, OH, where the fauna was dominated by *Pleurobema cordatum* and *Quadrula p. pustulosa*, which together comprised 39.9 percent of the assemblage (Miller and Payne 1993b). At a bed in the lower Tennessee River, the fauna was dominated by *A. p. plicata* (39.4 percent) and *Fusconaia ebena* (39.4 percent) (Miller, Payne, and Tippit 1992).

In comparison with other large-river mussel beds, mean total unionid density, which ranged from less than 10 to more than 130 individuals/square meter (Appendix A, Table A5), can be considered moderate to high. At an inshore and offshore site in the lower Tennessee River sampled in 1986 (32 quantitative samples were collected at each), total mussel density was 187.7 and 79.7 individuals/square meter, respectively (Way, Miller, and Payne 1989). In the middle Ohio River near Cincinnati, mussel density ranged from 4.4 to 52.4 individuals/square meter (Miller and Payne 1993b). In a survey of the upper Mississippi River at locations between RM 250 and 635, Miller et al. (1990) reported that total mussel density ranged from 5.2 to 333.2 individuals/square meter at 16 sites (10 quantitative samples were taken at each).

Densities of *C. fluminea* were moderate (<100/square meter) to high (1,621/square meter) in the project area. Although high at some locations, these values were similar to those found at large river mussel beds.

The number of individuals and species less than 30 mm total SL provides an estimate of recent recruitment. The overall percentage of individual native bivalves (excluding *C. fluminea*) less than 30 mm total SL was 20 to 50 percent. Occasionally, mussel beds are surveyed that exhibit evidence of very strong recent recruitment. At a mussel bed in the lower Ohio River, a single cohort of *F. ebena* with an average SL of 15.8 mm represented 71 percent of the population (Payne and Miller 1989). However, several years passed before strong recruitment for this species was noted. At sites in the Sunflower River, central Mississippi, virtually no evidence of recent recruitment was noted (Miller and Payne 1995).

The best mussel habitat in the project area was in Reaches 1, 2, and 3, near Walkiah Bluff. The mussels exhibited good evidence of recent recruitment, with moderate to high densities. Communities were not dominated by a single species, but two or three species were common to abundant. Few commercially valuable species were present, and virtually all thick-shelled species were quite small. *Corbicula fluminea* was present in moderate-to-high densities at some sites.

Potamilus inflatus in Project Area

Five complete shells of *P. inflatus* were collected in Reaches 6 and 7 in the project area (Figure 3). Specimens were in good condition, which indicates that they had been dead less than a year. Because these shells are extremely thin, it is likely that they would be destroyed or damaged by high water. Most shells were nearly adult size and 5 or more years old; one was about 60 mm long and was probably less than 5 years old. No live *P. inflatus* were collected. It is likely that with additional effort, live specimens could be found. However, there is no doubt that live *P. inflatus* exist in this river reach. Additional searching to verify the presence of live specimens is not warranted. Additional information on this species can be found in Chapter 5 of this report.

4 Effects of Water Diversion on Conditions in the Pearl and West Pearl Rivers

Background

Natural widening of Wilson Slough, Moore's Bayou, and Ice Box Slough has reduced the quantity of water in the Pearl River near Walkiah Bluff. This has reduced the amount of available aquatic habitat in Reaches 1 and 2, and to a lesser extent, Reaches 3 and 4. Personnel of the Vicksburg District plan to restore dependable low flow near Walkiah Bluff by placing a weir at Wilson Slough and completely closing Icebox Bayou, Moore's Bayou, Briar Patch Bayou, and an unnamed breakout. A pilot channel will be dredged through part of Reach 1 and most of Reach 2 to facilitate water movement. Three alternatives, which differ on the basis of the amount of water being directed into the Pearl River, are being considered. Increasing water level in the Pearl River will decrease water level in Wilson Slough.

Alternative 1 consists of diverting 30 percent of the flow down Wilson Slough with the remainder, 70 percent, sent into the Pearl River. Alternative 2 will send 50 percent of the water into the Pearl River and the other half down Wilson Slough. Alternative 3 will send 70 percent of the water into Wilson Slough and 30 percent into the Pearl River.

Although most freshwater mussels can withstand several days of atmospheric exposure, extended periods of reduced water level can cause mortality. Thin-shelled species, as well as mussels less than 50 mm long, will be affected first. Extremely high-velocity water, usually associated with high stage and discharge, can also negatively affect mussels. Mussels are usually found in water that ranges from 0.5 to 1.5 ft/sec, although some species survive well when velocity approaches zero. At velocities above 1.5 ft/sec, mussels become less common. Higher velocity water erodes substratum and dislodges mussels. The erosive effects of sediment particles in high-velocity water can damage the periostracum (a proteinaceous outer covering on mussel shells).

Effects of Project During Extreme Low and High Discharge

Effects of the proposed alternatives on the freshwater mussels in river reaches to be affected by water diversion were analyzed for extreme low water (October) and extreme high water (April). In October during baseline conditions, the 90-percent exceedence level was 102 cfs (Table 4). In April during baseline conditions, the 10-percent exceedence level was 21,700 cfs. The following describes effects of the three alternatives on low and high flow in the seven reaches:

Table 4
Differences in Discharge (in cubic feet/second) at the 90-Percent Exceedence Value in October (low-water conditions) and the 10-Percent Exceedence Value in March (high-water conditions) for Seven Reaches and Three Project Alternatives That Differ on the Amount of Water Directed Into Wilson Slough (30/70, 50/50, 70/30)

For 90-Percent Exceedence Values in October							
Reach	Baseline	30/70	Times Greater	50/50	Times Greater	70/30	Times Greater
1	102	981	9.6	821	8.0	447	4.4
2	22.4	981	43.8	821	36.7	447	20.0
3	102	981	9.6	821	8.0	447	4.4
4	102	981	9.6	821	8.0	447	4.4
5	1,260	449	0.4	683	0.5	970	0.8
6	1,760	956	0.5	1,180	0.7	1,490	0.8
7	1,760	956	0.5	1,180	0.7	1,490	0.8
For 10-Percent Exceedence Values in April							
Reach	Baseline	30/70	Times Greater	50/50	Times Greater	70/30	Times Greater
1	21,700	21,700	1.0	21,700	1.0	21,700	1.0
2	10,900	21,700	2.0	21,700	2.0	21,700	2.0
3	21,700	21,700	1.0	21,700	1.0	21,700	1.0
4	21,700	21,700	1.0	21,700	1.0	21,700	1.0
5	21,600	21,600	1.0	21,600	1.0	21,600	1.0
6	28,200	28,200	1.0	28,200	1.0	28,200	1.0
7	28,200	28,200	1.0	28,200	1.0	28,200	1.0

Note: Water level under baseline conditions is listed, plus water level in the various reaches as a result of three project alternatives. Following each column of water levels for each alternative is an estimate of the number of times greater (or less) that projected water levels differ from baseline conditions.

Reaches 1, 3, and 4

In Reaches 1, 3, and 4, Project Alternatives 1, 2, and 3 (30/70, 50/50, and 70/30 (Pearl River/Wilson Slough)) will cause an increase in discharge of 9.6, 8.0, and 4.4 times above baseline values during October (Table 4). The effect of these alternatives, to increase flow by variable amounts, will affect freshwater mussels and their habitat. The first alternative, which directs the highest percentage of water into the Pearl River, provides more aquatic habitat than Alternatives 2 and 3. The effects of the three alternatives during high flow (April) in Reaches 1, 3, and 4 are negligible (Table 4). Increasing the flow in the Pearl River near Walkiah Bluff will decrease flow in Wilson Slough.

Reach 2

Water losses through Moore's Bayou and Ice Box Bayou specifically affect Reach 2. The 90-percent exceedence value for this reach in October during baseline conditions is 22.4 cfs, which is substantially less than in the other reaches (Table 4). Each of the three alternatives has a substantial effect during low flow; increases from Alternatives 1, 2, and 3 are 43.8, 36.7, and 20.0 times greater than baseline conditions. However, discharge differences during high flow in April are only twice those of baseline conditions.

Reach 5

The effects of the three alternatives in Reach 5 is opposite that of Reaches 1-4 (Table 4). The three alternatives reduce discharge in Reach 5, with the greatest reduction caused by Alternative 1. Effects of diversion on discharge during low flow in October are 0.4 times (Alternative 1), 0.5 times (Alternative 2), and 0.8 times (Alternative 3) baseline conditions. Habitat value for mussels in Reach 5 could be stabilized slightly by a reduction in flow. During high discharge in April, none of the alternatives has a measurable effect on flow in this reach (Table 4). Presently, much of the substratum in Reach 5 is unstable and mussel densities are low. Alternative 1, which directs the least amount of water into Wilson Slough, will reduce water levels and increase channel stability to a greater extent than either of the other two alternatives.

Reaches 6 and 7

Reaches 6 and 7, which are downriver of the entrance of the Bogue Chitto River, are little affected by the three alternatives (Table 4). During low flow in April, the reduction in discharge is 0.5 times (Alternative 1), 0.7 times (Alternative 2), and 0.8 times (Alternative 3) baseline conditions. During high discharge in April, there are no effects of diversion.

Effects of Project on Water Velocity

In Reach 1 during baseline conditions, peak velocity of approximately 2 ft/sec is achieved at a discharge of 6,000 cfs (Figure 4). Mean velocity declines at higher flow because the river is out of the banks. The pattern for Reach 2 is similar, although values are higher; 2.5 ft/sec is achieved at a discharge of slightly less than 2,000 cfs. With the project at approximately 10,000 cfs, the peak velocity is 2.5 ft/sec and 4.0 cfs in Reaches 1 and 2, respectively. Water velocity and discharge are measurably higher with the project than during baseline conditions.

Differences between with-project and baseline conditions are greater in Reach 2 (a maximum velocity of 2.5 ft/sec versus nearly 4.0 ft/sec) than in Reach 1 (a maximum of 2 versus 2.5 ft/sec, Figure 5). With the project, there will probably be no measurable effects from higher velocity water in Reach 1. In Reach 2, a near doubling of water velocity is likely to erode fine-grained substratum. This could result in a loss of thin-shelled species that inhabit fine-grained sediments.

Effects of Project on Wetted Perimeter

Increased flow from the three project alternatives will increase the amount of available mussel habitat in Reaches 1 and 2 and, to some extent, 3 and 4 during low flow. In Reach 1, wetted perimeter will increase from 21.95 (baseline conditions) to 157.33, 152.93, and 139.76 at representative cross sections for Alternatives 1, 2, and 3 (Table 5). The amount of available habitat, in acres, will increase by approximately 6 times. The 30/70 alternative causes the greatest increase in wetted perimeter in Reaches 1-4 and the greatest habitat loss (although comparatively minor) in Reaches 5-7. An increase in flow in the Pearl River near Walkiah Bluff will decrease flow in Reaches 5-7. During high discharge, proposed water diversions affect wetted perimeter in Reaches 1 and 2 but not in Reaches 3-7 (Table 5).

In Reaches 1-4, the three alternatives will increase available aquatic habitat in the Pearl River (Table 6). The 30/70 alternative, which directs the majority of the water into the Pearl River, will have the greatest increase in habitat. In Reaches 1 and 2, increase in total acres will range from 29.5 to 41 acres, and in Reaches 3 and 4, the increase will range from 8.2 to 21 acres (Table 7). As a result of increased discharge in Reaches 1-4, the water levels and discharge will decline in Reaches 5-7. The three alternatives will cause a decrease in aquatic habitat of from 5 to 25 acres in Reaches 5-7. However, as described below, the habitat value of Reaches 5-7 will improve slightly because of increased substratum stability at reduced flow.

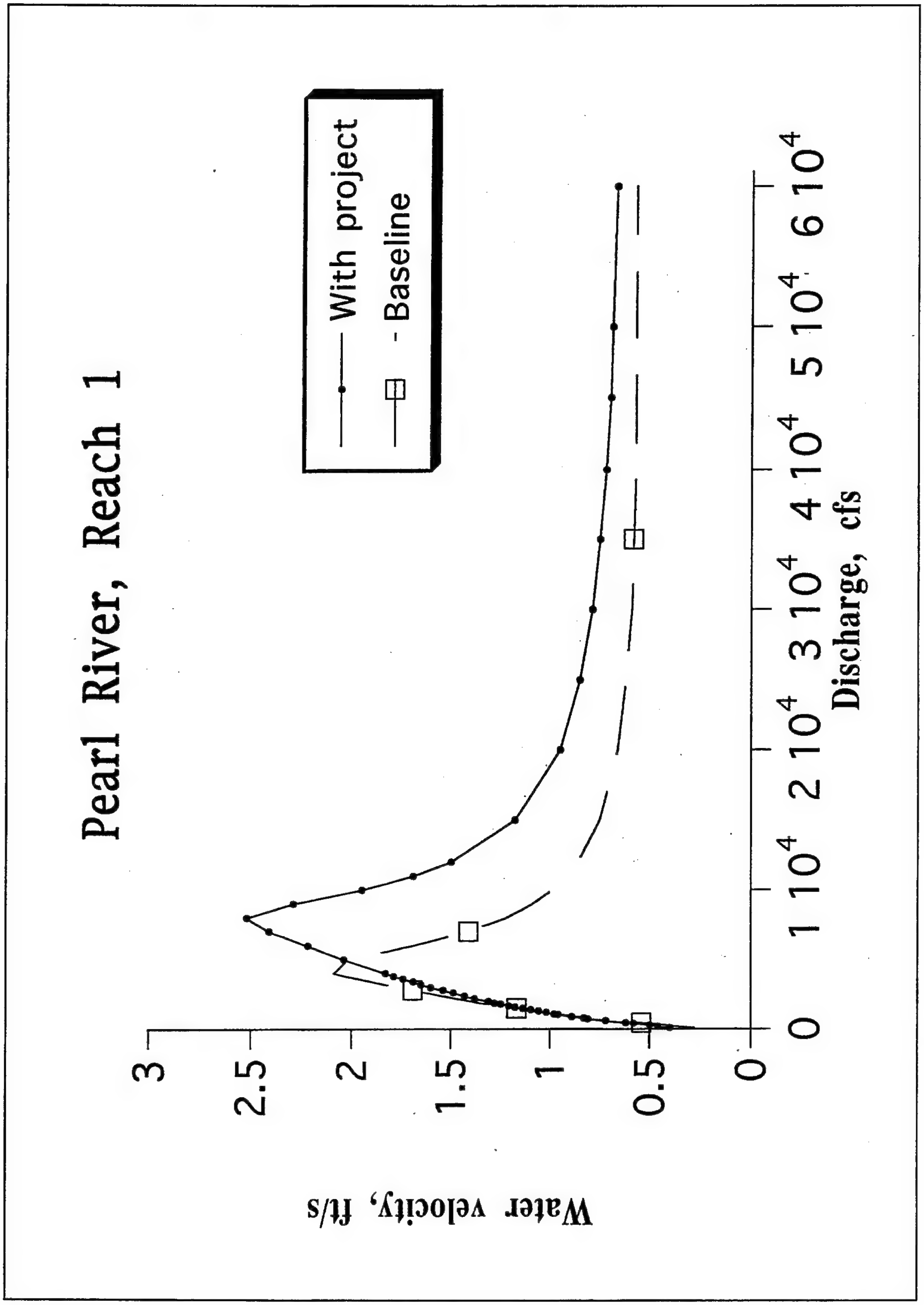

Figure 4. Relationship between river discharge and water velocity for Reach 1, Pearl River

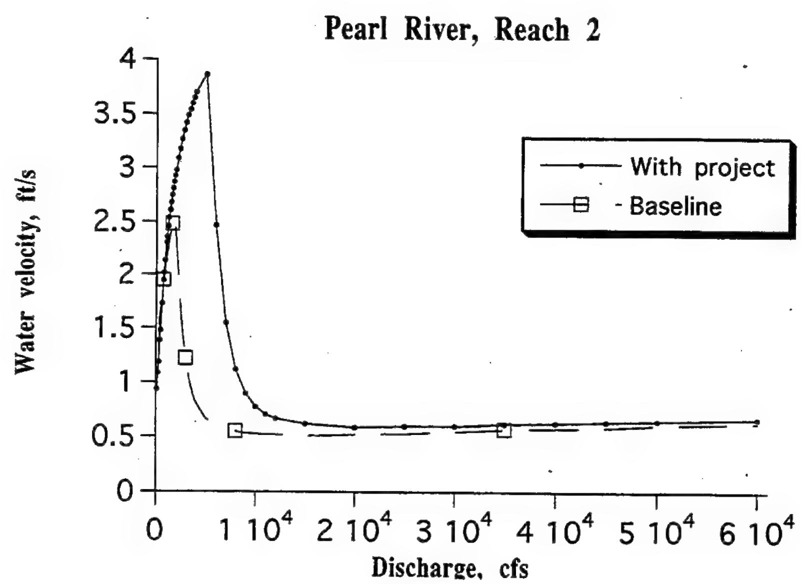

Figure 5. Relationship between river discharge and water velocity for Reach 2, Pearl River

Table 5
Change in Wetted Perimeter (WP) in Linear Feet for Seven Reaches of the Pearl and West Pearl Rivers for Three Project Alternatives That Differ on the Amount of Water Directed Into Wilson Slough (30/70, 50/50, 70/30)

For 90-Percent Exceedence Values in October											
	Baseline Conditions		30/70			50/50			70/30		
Reach	CFS	WP	CFS	WP	Difference, ft	CFS	WP	Difference, ft	CFS	WP	Difference, ft
1	102	21.96	981	157.33	135.37	821	152.93	130.97	447	139.76	117.80
2	22.4	13.43	981	77.1	63.67	821	73.44	60.01	447	64.91	51.48
3	102	165.9	981	177.28	11.38	821	175.21	9.31	447	170.37	4.47
4	102	146.66	981	158.57	11.91	821	156.4	9.74	447	151.33	4.67
5	1,260	102.76	449	92.75	-10.01	863	98.86	-3.90	970	100.44	-2.32
6	1,760	189.27	956	177.93	-11.34	1,180	182.9	-6.37	1,490	186.74	-2.53
7	1,760	102.95	956	83.71	-19.24	1,180	90.64	-12.31	1,490	98.86	-4.09

For 10-Percent Exceedence Values in April											
	Baseline		30/70			50/50 WP Change			70/30		
Reach	CFS	WP	CFS	WP	Difference, ft	CFS	WP	Difference, ft	CFS	WP	Difference, ft
1	21,700	3,268.81	21,700	6,880.24	3,611.43	21,700	6,880.24	3,611.43	21,700	6,880.24	3,611.43
2	10,900	2,822.47	21,700	7,933.4	5,110.93	21,700	7,933.4	5,110.93	21,700	7,933.4	5,110.93
3	21,700	11,623.1	21,700	11,623.1	0.00	21,700	11,623.1	0.00	21,700	11,623.1	0.00
4	21,700	3,054.15	21,700	3,054.15	0.00	21,700	3,054.15	0.00	21,700	3,054.15	0.00
5	21,600	457.74	21,600	457.74	0.00	21,600	457.74	0.00	21,600	457.74	0.00
6	28,200	3,508.18	28,200	3,508.18	0.00	28,200	3,508.18	0.00	28,200	3,508.18	0.00
7	28,200	774.46	28,200	774.46	0.00	28,200	774.46	0.00	28,200	774.46	0.00

Note: The difference between wetted perimeter under baseline condition and with each project alternative is also provided. These changes assume a constant baseline for a 50-year project. The amount of wetted perimeter, in feet, was established for specific discharge values (in cubic feet/second, CFS).

Table 6
Effects of Three Water-Diversion Alternatives on Aquatic Habitat in the Pearl River

Reach No.	Length, ft	Baseline Conditions		30/70			50/50			70/30		
		WP, ft	Acres	WP, ft	Acres	Change	WP, ft	Acres	Change	WP, ft	Acres	Change
1	7,700	21.95	3.88	157.33	27.8	23.9	152.93	27.0	23.2	139.76	24.7	20.8
2	7,300	13.43	2.25	77.1	12.9	10.7	73.44	12.3	10.1	64.91	10.9	8.6
3	18,300	165.90	69.70	177.28	74.5	4.8	175.21	73.6	3.9	170.37	71.6	1.9
4	59,000	146.66	198.64	158.57	214.8	16.1	156.4	211.8	13.2	151.33	205.0	6.3
5	5,375	102.76	12.68	92.75	11.4	-1.2	98.86	12.2	-0.5	100.44	12.4	-0.3
6	31,495	189.27	136.85	177.93	128.6	-8.2	182.9	132.2	-4.6	186.74	135.0	-1.8
7	34,320	102.95	81.11	83.71	66.0	-15.2	90.64	71.4	-9.7	98.86	77.9	-3.2

Table 7
Summary of Gains and Losses in Acres Resulting From Water Diversion in the Pearl River Near Walkiah Bluff, 1995

Reach No.	Baseline	30/70		50/50		70/30	
	Acres	Acres	Difference	Acres	Difference	Acres	Difference
1, 2	6.1	40.7	34.6	39.3	33.2	35.6	29.5
3, 4	268.3	289.3	20.9	285.4	17.1	276.5	8.2
5, 6, 7	230.6	206.0	-24.6	215.9	-14.8	225.3	-5.3

5 Environmental Effects of Water Diversion

Dredging Pilot Channel

Regardless of which of the three alternatives is chosen, a pilot channel will have to be excavated in Reaches 1 and 2 to facilitate water movement. The pilot channel will have a 20-ft bottom width with side slopes varying based on the natural angle of repose of the material excavated.

In Reaches 1 and 2, approximately 6 acres of aquatic habitat will be available at the 90-percent exceedence level in October (Table 8, Figure 6). This number was determined by multiplying the length of each reach by the wetted perimeter at the 90-percent exceedence level. The pilot channel will remove approximately 21 acres of aquatic habitat and mussels, more than twice the amount of available habitat at the 90-percent exceedence value. The channel should stabilize hydraulically within a year, although it could take at least 20 years to be completely recolonized with mussels. Figure 6 depicts the effects of dredging on aquatic habitat in Reaches 1 and 2 for the 50-year project life.

The following assumptions have been made for Reaches 1 and 2 with respect to dredging:

a. Available aquatic habitat will degrade to zero during the life of the project if there are no modifications to the channel to increase flow (Figure 6).

b. The overall mean density of mussels in shallow water in Reaches 1 and 2 prior to dredging was estimated at 50.5 and 48.5 mussels/square meter. In deep water of both reaches, density was estimated at 9.5 mussels/square meter (Table 8). In these reaches, it was assumed that approximately 60 percent of the existing mussel habitat was shallow and nearshore. The remaining habitat, about 40 percent, was deeper and less suitable for mussels. Approximately 2.5 million mussels were in shallow water, and 317,000 mussels were in the deeper areas of Reach 1 (See Table 8).

Table 8
Effects of Dredging on Mussels and Their Habitat (determined for 90-percent exceedence levels in October)

Reach No.	Length, ft	WP, ft	Acres Avail	Width, ft	Acres Lost	CFS
1	7,700	22.0	3.9	60	10.6	102.0
2	7,300	13.4	2.3	60	10.1	22.4
Total	15,000	35.4	6.1		20.7	

Mussel Density, Individuals/square meter						
	Existing Bars		Outside Bars		Overall Mean	
Reach No.	Shallow	Deep	Shallow	Deep	Shallow	Deep
1	55	5	5	1	50.5	9.5
2	35	5	5	1	48.5	9.5

Mussels Lost by Dredging			
Reach No.	Shallow	Deep	Total
1	1,300,559	163,106	1,463,665
2	1,184,166	154,633	1,338,799
Total	2,484,724	317,740	2,802,464

c. As a result of dredging, approximately 2.8 million mussels would be lost in Reaches 1 and 2 (Table 8). This includes all of the area within the 90-percent exceedence levels as well as area outside this contour. During the 1995 season, living mussels were in extremely shallow water (several inches deep) that were outside the 90-percent exceedence level. Therefore, it is unlikely that dredging would totally eliminate mussels from Reaches 1 and 2.

Effects of Water Diversion on Mussel Habitat

Based upon measurements of water velocity and substratum types, HSI values for freshwater mussels were assigned to river reaches (Miller et al. 1987). These HSI values, plus the total number of available acres of aquatic habitat, were used to calculate habitat units (HU) and average annualized habitat units (AAHU) (HU/50). These data appear in Tables 9-11 for Reaches 1 and 2, 3 and 4, and 5-7, respectively. In Reaches 1-4, without the project, available aquatic habitat (and its value) would decline to 0.0 by Year 50 (Figures 6 and 7). In Reaches 5-7, baseline conditions would not change in 50 years without the project (Figure 8).

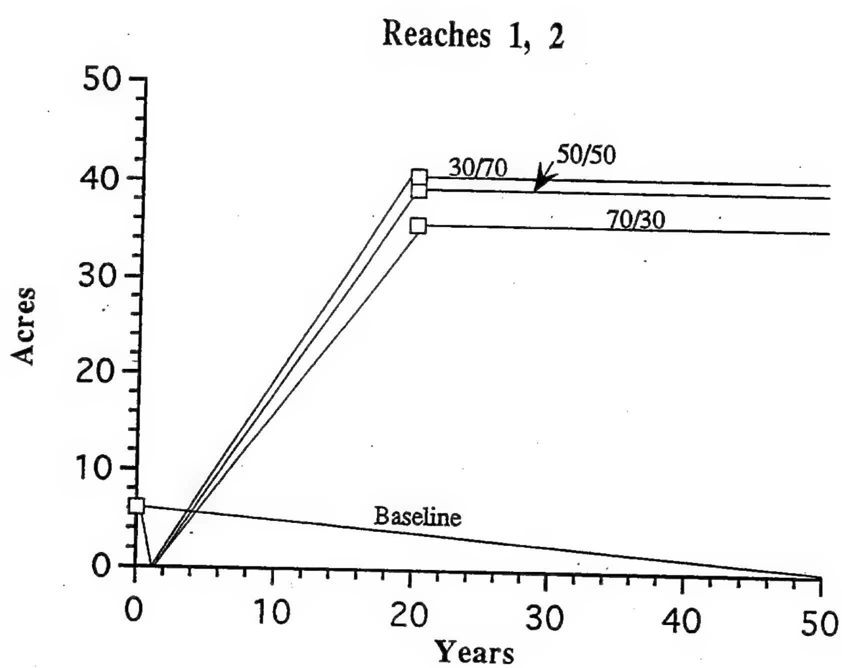

Figure 6. Effects of dredging a pilot channel and three water-diversion alternatives in Reaches 1 and 2

Table 9
Change in Habitat Units in Reaches 1 and 2 Resulting From Three Water-Diversion Alternatives Near Walkiah Bluff, Pearl River

Condition	Time 1	Time 2	Acres-Time 1	Acres-Time 2	HSI-Time 1	HSI-Time 2	HU	AAHU
30/70 Alternative								
Baseline	0	50	6.1	0	1	0	101.7	2.0
With Project	0	1	6.1	0	1	0	2.0	0.0
With Project	1	20	0	40.7	1	1	386.7	7.7
With Project	21	50	40.7	40.7	1	1	1,180.3	23.6
Total							1,569.0	31.4
50/50 Alternative								
With Project	0	1	6.1	0	1	0	2.0	0.0
With Project	1	20	0	39.3	0	1	248.9	5.0
With Project	21	50	39.3	39.3	1	1	1,139.7	22.8
Total							1,390.6	27.8
70/30 Alternative								
With Project	0	1	6.1	0	1	0	2.0	0.0
With Project	1	20	0	35.6	0	1	225.5	4.5
With Project	21	50	35.6	35.6	1	1	1,032.4	20.6
Total							1,259.9	25.2

Note: HU = Habitat units; AAHU = Average annualized habitat units.

In Reaches 1 and 2, with the project, AAHU for the 30/70, 50/50, and 70/30 alternatives were 31.4, 27.8, and 25.2, respectively. For Reaches 3 and 4, AAHU were 158.7, 142.6, and 138.2. Higher AAHU result from shunting less water down Wilson Slough (and relatively more down the Pearl River, the 30/70 alternative). The increase in AAHU for Reaches 1-4 was assumed to come entirely from an increase in available habitat due to increased water. The habitat value was assumed not to change because of the project.

Habitat value in Reaches 5-7 increases by shunting a comparatively larger percentage of water into the Pearl River; decreased flow will improve substratum stability slightly in Wilson Slough and farther downriver. Existing HSI values in Reaches 5-7 were set at 0.3. The HSI values for the 30/70, 50/50, and 70/30 alternatives were 0.5, 0.45, and 0.4, respectively, which reflects the increased value of shunting less water into Wilson Slough. In Reaches 5-7,

Table 10
Change in Habitat Units in Reaches 3 and 4 Resulting From Three Water-Diversion Alternatives Near Walkiah Bluff, Pearl River

Condition	Time 1	Time 2	Acres-Time 1	Acres-Time 2	HSI-Time 1	HSI-Time 2	HU	AAHU
30/70 Alternative								
Baseline	0	50	268.3	0.0	0.5	0.5	3,353.8	67.1
With Project	0	1	268.3	289.3	0.5	0.5	139.4	2.8
With Project	1	50	289.3	289.3	0.6	0.5	7,796.6	155.9
Total							7,936.0	158.7
50/50 Alternative								
With Project	0	1	268.3	285.4	0.5	0.5	138.4	2.8
With Project	1	50	285.4	285.4	0.5	0.5	6,992.3	139.8
Total							7,130.7	142.6
70/30 Alternative								
With Project	0	1	268.3	276.5	0.5	0.5	136.2	2.7
With Project	1	50	276.5	276.5	0.5	0.5	6,774.3	135.5
Total							6,910.5	138.2

Note: HU = Habitat units; AAHU = Average annualized habitat units.

Table 11
Change in Habitat Units in Reaches 5-7 Resulting From Three Water-Diversion Alternatives Near Walkiah Bluff, Pearl River

Condition	Time 1	Time 2	Acres-Time 1	Acres-Time 2	HSI-Time 1	HSI-Time 2	HU	AAHU
30/70 Alternative								
Baseline	0	50	230.6	230.6	0.3	0.3	3,459.0	69.2
With Project	0	1	230.6	206	0.3	0.5	86.9	1.7
With Project	1	50	206	206	0.5	0.5	5,047.0	100.9
Total							5,133.9	102.7
50/50 Alternative								
With Project	0	1	230.6	215.9	0.3	0.45	83.5	1.7
With Project	1	50	215.9	215.9	0.45	0.45	4,760.6	95.2
Total							4,844.1	96.9
70/30 Alternative								
With Project	0	1	230.6	225.3	0.3	0.4	79.1	1.6
With Project	1	50	225.3	225.3	0.4	0.4	4,415.9	88.3
Total							4,495.6	89.9

Note: HU = Habitat units; AAHU = Average annualized habitat units.

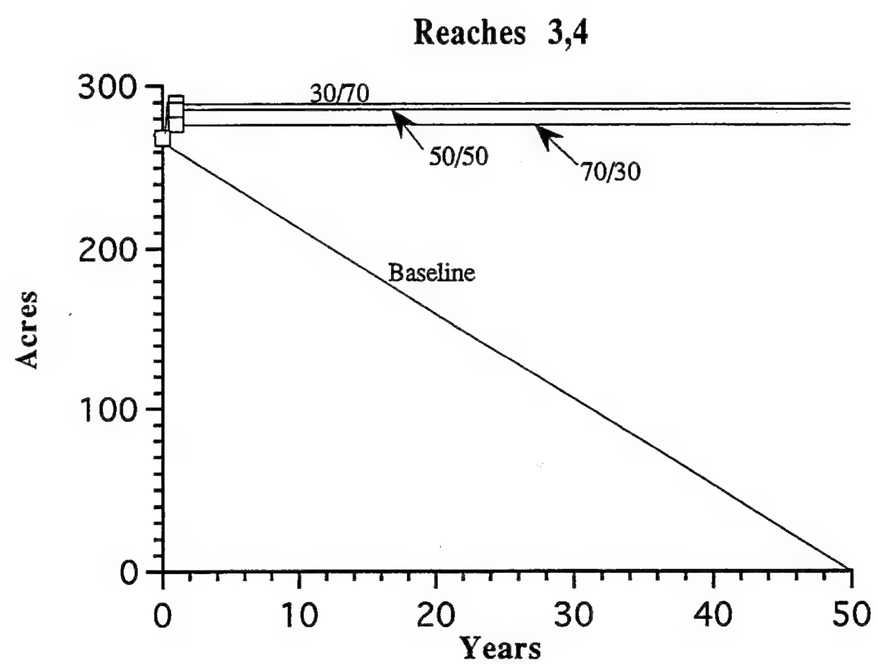

Figure 7. Effects of three water-diversion alternatives on aquatic habitat in Reaches 3-4

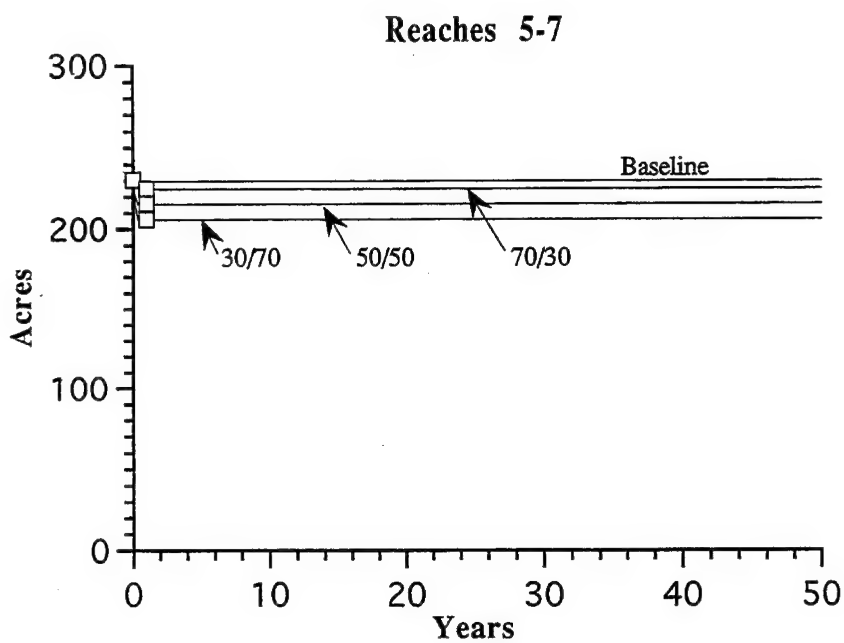

Figure 8. Effects of three water-diversion alternatives on aquatic habitat in Reaches 5-7

AAHU values were 292.8, 267.3, and 253.5 for the 30/70, 50/50, and 70/30 alternatives, respectively.

Project-induced changes in AAHU and annualized acres for the three alternatives appear in Tables 12 and 13. The 30/70 alternative, which directs the greatest percentage of water into the Pearl River and the least into Wilson Slough, causes the greatest positive net change in AAHU. This alternative will cause a net change in 154.5 AAHU, which is greater than the 50/50 (129.0 AAHU) or the 70/30 alternative (115.0 AAHU). Gains in the quantity of aquatic habitat in Reaches 1-4 are offset to some extent by losses in aquatic habitat in Reaches 5-7 (Table 13). The 30/70, 50/50, and 70/30 alternatives cause a net change in annualized acres of 158.9, 163.8, and 161.4 acres, respectively.

Table 12
Change in Average Annual Habitat Units Resulting From Three Water-Diversion Alternatives Near Walkiah Bluff, Pearl River

		With the Project			Net Change		
Reaches	**Baseline**	**30/70**	**50/50**	**70/30**	**30/70**	**50/50**	**70/30**
1, 2	2.0	31.4	27.8	25.2	29.3	25.8	23.2
3, 4	67.1	158.7	142.6	138.2	91.6	75.5	71.1
5 - 7	69.2	102.7	96.9	33.5	33.5	27.7	20.7
Total	183.3	292.8	267.3	253.3	154.5	129.0	115.0

Table 13
Change in Annualized Acres Resulting From Three Water-Diversion Alternatives Near Walkiah Bluff, Pearl River (assumes a habitat value equal to 1.0)

		With the Project			Net Change		
Reaches	**Baseline**	**30/70**	**50/50**	**70/30**	**30/70**	**50/50**	**70/30**
1, 2	3.1	31.4	30.3	27.5	28.4	27.3	24.4
3, 4	134.2	289.1	285.2	276.4	154.9	151.1	142.3
5 - 7	230.6	206.2	216.0	225.4	-24.4	-14.6	-5.2
Total	367.8	526.7	531.6	529.2	158.9	163.8	161.4

Potamilus inflatus

Potamilus inflatus, listed as threatened by the U.S. Fish and Wildlife Service (FWS) in 1990, has also been found in the Amite River, Louisiana (U.S. Fish and Wildlife Service 1994). Stem (1976) reported that *P. inflatus* usually inhabits soft, stable substratum in slow to moderate current. Hartfield (1988a,b) reported that this species is found in sand, mud, and sandy gravel,

but not in large gravel or armored gravel. *Potamilus inflatus* is similar to the pink heelsplitter, *Potamilus ohiensis*; however, the latter is less inflated and found in sloughs and lakes where inflated heelsplitters are usually not collected.

In 1993 and 1994, scientists from WES conducted a survey of the Black Warrior and Tombigbee rivers, Alabama, for *P. inflatus* (Miller 1994; Miller, Payne, and Armistead, In Preparation). The purpose was to investigate the distribution of this species with reference to maintenance dredging. Miller (1994) reported that density ranged from 0.104 to 4.817 individuals/100 m^2 in silt and sand on or near dredged material disposal areas. In 1994, Miller reported mean densities of 0.5 individuals/100 m^2 at areas used for disposal within less than 12 months of sampling. Areas that were similar, but not affected by disposal, had densities of 0.97 individuals/100 m^2. It was concluded that *P. inflatus* had the ability to rapidly recolonize disturbed areas.

The densest population of this species in the Black Warrior River (1.73 individuals/100 m^2) was a reach with extremely low river gradient, 0.4 ft/mile. These values are extremely low; many collectors and commercial fishermen would not work a bed with mussels less dense than one individual/square meter. Based upon quantitative sampling at a gravel bar in the Tombigbee River, Miller, Payne, and Armistead (In Preparation) estimated *P. inflatus* densities at 30 individuals/100 m^2. Although it comprised a small percentage of the community, it was actually numerically more abundant in gravel than in fine-grained sand and silt. Although *P. inflatus* is usually reported from fine-grained substratum, it obviously can survive in gravel.

In early 1994, divers searched a sandbar in the Black Warrior River where dredged material had been placed in 1993. They found two inflated heelsplitters that were about 25 mm (1 in.) long and slightly more than 1 year old. These mussels clearly had a single growth ring, plus a few millimeters beyond that ring that provided evidence of growth in early 1994. It is apparent that individuals were the result of recruitment early in 1993. In addition, divers found adult-sized inflated heelsplitters at this location. These mussels had either washed in after disposal or else had survived the disposal process. It is most likely that they were carried into the disposal area by high flow after dredging.

Based upon the 2-year survey of the Black Warrior and Tombigbee rivers, the following conclusions can be made concerning the inflated heelsplitter in the Pearl River:

a. This species can rapidly colonize recently dredged areas. Rapid recolonization takes place via natural recruitment (the immature mussels being dropped by a host fish) and by juvenile or adult mussels being carried in by river currents. Therefore, this species is likely to quickly recolonize dredged areas in the Pearl River. In July 1995, two fresh dead *P. inflatus* were collected in the West River, St. Tammany Parish (George, Dickerson, and Reine 1996). The first was taken at the

confluence of the Pearl River with the Pearl River Canal, and the second was taken under the I-59 Bridge. Based upon their position in the substratum, it appeared that both had died in situ and had not washed in from another location. However, it should be noted that none was taken in this project area.

b. During the 1994 study in Alabama, a series of field tests were conducted to determine the ability of heelsplitters to reburrow into the substratum after being dislodged. Depending on size, it took from 5 to 90 min for a mussel to completely rebury. Small mussels moved quickly; the larger individuals required the longest time. These findings indicate that specimens disturbed by high water or dredging in the Pearl River would have the ability to quickly reburrow if suitable substratum is present.

c. Experiments were also conducted to evaluate the ability of mussels to extricate themselves after being buried in sand either 4 or 6 in. deep. Experiments had to be terminated after 4 to 6 hr since mussels had moved very little. Based on these results, it is likely that mussels covered by disposed sand or silt are unlikely to be able to extricate themselves and will likely perish.

d. Before initiating the 1993-94 study in Alabama, there was speculation that areas with moderate-to-high-density populations of *P. inflatus* (at least greater than one individual/square meter) could be found. No such areas were located; therefore, it is likely that *P. inflatus* has a very low density at suitable habitat in the Pearl River.

Dreissena polymorpha

The first report of the zebra mussel in North America was from Lake St. Clair in June 1988 (Hebert, Muncaster, and Mackie 1989). By late summer 1989, zebra mussels had spread downstream into the Detroit River, Lake Erie, Niagara River, and western Lake Ontario (Griffiths, Kovalak, and Schloesser 1989). By late September 1990, zebra mussels had spread through Lake Ontario and down the St. Lawrence River to Massena, NY. In June 1991, biologists from the Illinois Natural History Survey found adult zebra mussels at Illinois River Miles 50, 60, and 110 (Moore 1991; Sparks and Marsden 1991).

By early January 1993, zebra mussels had spread throughout most of the inland waterway system. They probably reached upriver sites on hulls of commercial navigation vessels (Keevin, Yarbrough, and Miller 1992). They were found in the lower Mississippi River as far south as Vicksburg, MS, and in the upper Mississippi River near St. Paul, MN (*Dreissena polymorpha* Information Review 1992).

There is every reason to believe that this species will continue to spread throughout North America where suitable habitat exists (Strayer 1990). However, no zebra mussels were collected during the 1995 survey of the Pearl River. However, since this species does not tolerate saline conditions, and the Pearl River drains into the Gulf, it is not likely to be brought in from the south. Zebra mussels could enter the Pearl River from an upriver site in central Mississippi. If they enter the river, they are likely to find suitable habitat on existing gravel bars. Typically, the zebra mussel, like other exotic species, reaches extremely high densities (often near 100,000 individuals/square meter), then decline to an equilibrium value within several years.

Summary

A survey for freshwater mussels, with specific attention directed toward the threatened heelsplitter mussel, *P. inflatus*, was conducted in seven reaches of the Pearl River, Holmes Bayou, Wilson Slough, and the West Pearl River near Picayune, MS. The purpose was to assess environmental effects of three alternatives designed to direct water into the Pearl River near Walkiah Bluff. Natural widening of sloughs and bayous in the area has caused water to drain away from the Walkiah Bluff area.

The project area contains a rich and diverse assemblage of mussels. Recruitment is high, and where suitable substratum exists, high-density populations of mussels were found. The nonindigenous *C. fluminea* was collected, but there was no evidence of *D. polymorpha*, introduced into this country in the late 1980s. Shells of the threatened inflated heelsplitter were found, although no live specimens were collected. This species exists in the Pearl River, although not near the area to be affected by the diversion project.

The three water diversion projects will increase the quality and quantity of mussel habitat in the Pearl River near Walkiah Bluff. Raising water levels will protect existing areas during low flow and increase the quantity of habitat available for mussels. Mussels will be lost by construction of a pilot channel to remove water, and this area could take up to 20 years to recolonize. A result of increasing flow in Reaches 1 and 2 will be a decrease in flow in Reaches 5-7. This will have a minor positive effect on substratum stability in these reaches.

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Appendix A Quantitative Data on Freshwater Mussels From the Walkiah Bluff Project, Pearl River, 1995

Table A1
Percent Abundance of Freshwater Mussels Collected Using Quantitative Methods at Site 1, Reach 1, Pearl River, 1995

Species	Subsite 1	Subsite 2	Subsite 3	Total
Q. refulgens	35.92	0.00	51.76	39.05
O. reflexa	33.06	37.50	18.82	29.59
Q. apiculata	19.18	12.50	9.41	16.57
T. donaciformis	6.94	12.50	11.76	8.28
P. dombeyanus	1.22	12.50	2.35	1.78
Q. rumphiana	1.63	0.00	0.00	1.18
F. ebena	0.82	0.00	1.18	0.89
L. fragilis	0.00	0.00	2.35	0.59
F. cerina	0.41	0.00	1.18	0.59
T. verrucosa	0.41	0.00	1.18	0.59
U. tetralasmus	0.00	12.50	0.00	0.30
P. purpuratus	0.00	12.50	0.00	0.30
Q. quadrula	0.41	0.00	0.00	0.30
Total individuals	245	8	85	338
Total species	10	6	9	13
% Individuals <30 mm	17.14	12.5	71.76	30.76
% Species <30 mm	70	16.67	66.67	61.54
Menhinick's Index	0.63	2.12	0.98	0.71
Species diversity (H')	1.46	1.67	1.46	1.54
Evenness	0.78	1.94	0.64	0.73

Table A2
Percent Occurrence of Freshwater Mussels Collected Using Quantitative Methods at Site 1, Reach 1, Pearl River, 1995

Species	Subsite 1	Subsite 2	Subsite 3	Total
Q. refulgens	100.00	0.00	80.00	60.00
O. reflexa	100.00	30.00	40.00	56.67
Q. apiculata	90.00	10.00	40.00	46.67
T. donaciformis	50.00	10.00	50.00	36.67
P. dombeyanus	30.00	10.00	20.00	20.00
Q. rumphiana	10.00	0.00	0.00	3.33
F. ebena	20.00	0.00	10.00	10.00
L. fragilis	0.00	0.00	10.00	3.33
F. cerina	10.00	0.00	10.00	6.67
T. verrucosa	10.00	0.00	10.00	6.67
U. tetralasmus	0.00	10.00	0.00	3.33
P. purpuratus	0.00	10.00	0.00	3.33
Q. quadrula	10.00	0.00	0.00	3.33
Total samples	10	10	10	30

Table A3
Percent Abundance of Freshwater Mussels Collected at Site 3, Reach 1, Pearl River, 1995

Species	Subsite 1	Subsite 2	Subsite 3	Total
P. dombeyanus	29.09	0.00	12.50	27.53
Q. apiculata	26.06	0.00	0.00	24.16
G. rotundata	13.33	0.00	0.00	12.36
O. reflexa	9.70	0.00	0.00	8.99
Q. quadrula	6.06	0.00	12.50	6.18
Q. refulgens	3.03	40.00	12.50	4.49
P. purpuratus	2.42	0.00	25.00	3.37
A. suborbiculata	1.82	0.00	12.50	2.25
L. teres	1.21	20.00	0.00	1.69
U. imbecillis	1.82	0.00	0.00	1.69
L. fragilis	0.61	40.00	0.00	1.69
L. claibornensis	1.82	0.00	0.00	1.69
E. crassidens	1.21	0.00	0.00	1.12
V. lienosa	0.61	0.00	12.50	1.12
Q. rumphiana	0.61	0.00	12.50	1.12
A. confragosus	0.61	0.00	0.00	0.56
Total individuals	165	5	8	178
Total species	16	3	7	16
% Individuals <30 mm	40.34	25.09	25.19	28.63
% Species <30 mm	63.63	47.37	64.29	57.14
Menhinick's Index	1.24	1.34	2.47	1.19
Species diversity (H')	2.02	1.05	1.91	2.14
Evenness	0.69	2.14	4.71	0.69

Table A4
Frequency of Occurrence of Freshwater Mussels Collected at Site 3, Reach 1, Pearl River, 1995

Species	Site 1	Site 2	Site 3	Total
P. dombeyanus	100.00	0.00	20.00	40.00
Q. apiculata	100.00	0.00	0.00	33.33
G. rotundata	80.00	0.00	0.00	26.67
O. reflexa	80.00	0.00	0.00	26.67
Q. quadrula	60.00	0.00	20.00	26.67
Q. refulgens	80.00	40.00	20.00	46.67
P. purpuratus	60.00	0.00	20.00	26.67
A. suborbiculata	40.00	0.00	20.00	20.00
L. teres	40.00	20.00	0.00	20.00
U. imbecillis	40.00	0.00	0.00	13.33
L. fragilis	20.00	40.00	0.00	20.00
L. claibornensis	40.00	0.00	0.00	13.33
E. crassidens	40.00	0.00	0.00	13.33
V. lienosa	20.00	0.00	20.00	13.33
Q. rumphiana	20.00	0.00	20.00	13.33
A. confragosus	20.00	0.00	0.00	6.67
Total samples	5	5	5	15

Table A5
Frequency of Abundance of Freshwater Mussels Collected Using Quantitative Methods at Three Subsites at Site 17, Reach 3, Pearl River, 1995

Species Name	Subsite 1	Subsite 2	Subsite 3	Total
Q. refulgens	61.32	47.62	25.33	46.95
T. donaciformis	11.32	10.88	18.67	12.80
T. verrucosa	0.94	0.00	16.00	3.96
O. reflexa	15.09	15.65	12.00	14.63
P. purpuratus	1.89	1.36	6.67	2.74
Q. apiculata	3.77	12.24	5.33	7.93
L. fragilis	1.89	3.40	4.00	3.05
P. dombeyanus	2.83	4.08	4.00	3.66
Q. quadrula	0.00	2.72	2.67	1.83
G. rotundata	0.94	1.36	2.67	1.52
P. imbecillis	0.00	0.00	2.67	0.61
U. declivis	0.00	0.68	0.00	0.30
Total individuals	106	147	75	328
Total species	9	10	11	12
% Individuals <30 mm	42.45	33.33	40.00	37.80
% Species <30 mm	66.67	80.00	81.82	91.67
Menhinick's Index	0.87	0.82	1.27	0.66
Species diversity (H')	1.29	1.64	2.09	1.74
Evenness	0.54	0.63	0.86	0.58

Table A6
Frequency of Occurrence of Freshwater Mussels Collected Using Quantitative Methods at Three Subsites at Site 17, Reach 3, Pearl River, 1995

Species name	Subsite 1	Subsite 2	Subsite 3	Total
Q. refulgens	100.00	100.00	100.00	100.00
T. donaciformis	100.00	100.00	80.00	93.33
T. verrucosa	20.00	0.00	40.00	20.00
O. reflexa	100.00	100.00	60.00	86.67
P. purpuratus	40.00	40.00	80.00	53.33
Q. apiculata	40.00	80.00	40.00	53.33
L. fragilis	40.00	40.00	40.00	40.00
P. dombeyanus	40.00	60.00	40.00	46.67
Q. quadrula	0.00	80.00	40.00	40.00
G. rotundata	20.00	40.00	40.00	33.33
P. imbecillis	0.00	0.00	20.00	6.67
U. declivis	0.00	20.00	0.00	6.67
Total samples	5	5	5	15

Table A7
Percent Abundance and Occurrence of Freshwater Mussels Collected Using Quantitative Methods at Site 29, Reach 2, Pearl River, 1995

Species	Percent Abundance	Percent Occurrence
T. donaciformis	27.91	60.00
Q. refulgens	18.60	60.00
L. fragilis	11.63	60.00
P. purpuratus	9.30	80.00
P. dombeyanus	6.98	20.00
F. cerina	6.98	40.00
V. lineosa	4.65	40.00
L. teres	4.65	40.00
O. reflexa	2.33	20.00
Q. quadrula	2.33	20.00
G. rotundata	2.33	20.00
L. claibornensis	2.33	20.00
Total individuals	43	
Total species	12	
Total samples	5	
% Individuals <30 mm	39.53	
% Species <30 mm	25.00	
Menhinick's Index	1.83	
Species diversity (H')	2.15	
Evenness	0.88	

Table A8
Mean Density (Individuals/square meter) and Standard Error (SE) of *Corbicula fluminea* and Native Mussels (Unionidae) at Selected Sites in the Pearl River, Mississippi and Louisiana, 1995

Date	Site	Location	Reach	No. of Samples	*C. fluminea*		Unionidae	
					Mean Density	SE	Mean Density	SE
21 Aug	1	RDB	1	10	1.2	0.6	98.0	13.7
21 Aug	1	RDB	1	10	8.0	2.5	3.2	0.8
21 Aug	1	RDB	1	10	31.6	11.6	34.0	10.9
22 Aug	3	LDB	1	5	242.4	37.6	132.0	12.9
22 Aug	3	Channel	1	5	53.6	9.5	4.0	1.6
22 Aug	3	RDB	1	5	8.8	2.9	6.4	2.7
27 Sep	29	Channel	2	5	1,620.8	823.5	0.0	0.0
27 Sep	29	LDB	2	5	82.4	71.9	34.4	9.0
24 Sep	17	LDB	3	5	37.6	2.9	92.8	9.8
24 Sep	17	Channel	3	5	44.8	7.7	117.6	12.0
24 Sep	17	RDB	3	5	130.4	15.5	60.0	9.9

Note: RDB = Right descending bank; LDB = Left descending bank.

Appendix B
Summary of Qualitative Data Collected August-October 1995 in the Pearl and West Pearl Rivers for the Walkiah Bluff Project

Table B1
Results of Qualitative Sampling for Freshwater Mussels on the Pearl River Upriver of Wilson Slough, Through Wilson Slough to the Lateral Canal in the West Pearl River (Reaches 6 and 7)

	Site 5						Site 9			Site 11	
Species	Channel	RDB	LDB	Site 6	Site 7	Site 8	RDB	LDB	Site 10	RDB	LDB
O. reflexa	0.00	53.21	33.33	0.00	0.00	5.00	0.00	0.00	0.00	23.68	6.67
Q. apiculata	0.00	29.49	0.00	0.00	0.00	10.00	8.33	0.00	0.00	46.05	0.00
A. imbecillis	0.00	0.00	0.00	6.00	0.00	5.00	8.33	0.00	0.00	0.00	13.33
Q. refulgens	0.00	3.85	33.33	0.00	0.00	25.00	33.33	0.00	0.00	5.26	0.00
P. dombeyanus	0.00	3.53	0.00	0.00	0.00	0.00	8.33	0.00	0.00	2.63	0.00
Q. quadrula	0.00	2.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L. fragilis	0.00	0.00	33.33	0.00	0.00	5.00	8.33	0.00	0.00	0.00	6.67
E. crassidens	0.00	2.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. rotundata	0.00	1.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26	0.00
L. ornata	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
T. verrucosa	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L. teres	0.00	0.00	0.00	0.00	0.00	15.00	16.67	0.00	0.00	0.00	13.33
L. claibornensis	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	1.32	0.00
F. cerina	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F. ebena	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P. purpuratus	0.00	0.32	0.00	0.00	0.00	5.00	16.67	0.00	100.00	15.79	20.00
P. beadleanum	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total individuals	0	312	3	0	0	20	12	0	1	76	15
Total species	0	12	3	0	0	11	7	0	1	7	5
Total samples	2	2	2	1	1	1	1	1	1	1	2
Total search time	0	20	20	10.0	0.0	60.0	40.0	30.0	30.0	20.0	45.0
Mussels/minute	0.0	15.6	0.2	0	0	0.3	0.3	0	0	3.80	0.30

Note: Right descending bank = RDB; Left descending bank = LDB.

Table B2
Results of Qualitative Sampling for Freshwater Mussels at Sites 35-40 (Reach 7), Plus Site 41 in the Mouth of the Lateral Canal, in the West Pearl River, 1995 (Shallow-water sites were along the shore and sampled by nondivers; deep-water sites were in the channel and sampled by divers)

	Sites 35 - 40			
Species	1-2 m	Shallow	Deep	Site 41
A. imbecillis	0.00	2.17	0.00	0.00
A. p. plicata	0.00	0.36	0.00	0.00
F. ebena	0.79	0.00	0.00	0.00
G. rotunda	0.20	1.81	0.00	0.00
L. claibornensis	0.00	0.72	0.00	0.00
L. ornata	0.00	0.36	3.23	0.00
L. teres	0.00	8.33	0.00	0.00
L. fragilis	0.20	0.36	0.00	2.86
O. reflexa	16.87	19.20	3.23	5.71
P. dombeyanus	0.00	6.52	0.00	0.00
P. purpuratus	3.57	19.57	3.23	8.57
P. grandis	0.00	0.00	0.00	2.86
Q. apiculata	6.15	13.41	0.00	20.00
Q. quadrula	0.40	1.45	3.23	0.00
Q. refulgens	70.83	18.12	80.65	60.00
T. texasensis	0.00	3.99	3.23	0.00
T. verrucosa	0.99	2.17	0.00	0.00
V. lienosa	0.00	1.45	3.23	0.00
Total individuals	504	276	31	35
Total species	7	15	7	6
Total time	150	270	45	150
Total samples	4	6	1	1
Mussels/minute	3.36	1.02	0.69	0.2

Table B3
Pearl River from the Head of Wilson Slough Downriver to the Start of Ice Box Slough (Sites 1, 3, and 4 in Reach 1) and at Site 2, Reach 2, Near Walkiah Bluff in the Pearl River, 1995 (Shallow water sites were along the shore and sampled by nondivers; deep water sites were in the channel and sampled by divers)

		Site 2		Site 3		Site 4		
Species	Site 1	Shallow	Deep	Shal-low	Deep	RDB	LDB	Channel
Q. refulgens	37.82	39.52	40.38	22.30	76.49	31.40	30.87	32.04
O. reflexa	38.31	33.69	21.14	19.86	19.61	40.70	38.93	47.51
Q. apiculata	18.02	16.71	23.47	34.49	0.00	23.26	20.81	16.02
P. purpuratus	0.00	2.65	2.75	4.88	1.96	1.16	1.34	0.00
F. ebena	1.14	0.53	3.59	1.05	0.00	0.00	5.37	1.66
P. dombeyanus	1.79	0.00	0.85	5.47	0.00	1.16	0.00	0.55
Q. quadrula	0.97	0.53	2.96	2.79	0.00	1.16	0.00	1.10
T. verrucosa	1.14	0.53	0.21	2.44	0.00	0.00	0.67	0.55
F. cerina	0.49	2.12	0.85	1.37	0.00	0.00	0.00	0.00
P. beadleanum	0.00	0.27	1.06	2.09	0.00	0.00	0.67	0.55
T. donaciformis	0.32	0.80	1.27	0.35	0.00	1.16	0.00	0.00
E. crassidens	0.00	1.06	0.85	1.05	0.00	0.00	0.67	0.00
G. rotunda	0.00	0.27	0.00	0.68	1.79	0.00	0.00	0.00
U. imbecillis	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00
V. lienosa	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00
L. subrostrata	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00
A. p. plicata	0.00	0.00	0.00	0.35	0.00	0.00	0.67	0.00
Total individuals	616	377	473	282	56	86	149	181
Total species	9	15	13	17	5	8	9	
Total time, minute		40	40	20	20	20	20	20
Total samples	32	4	4	2	2	2	2	9.1
Mussels/minute		9.65	12.08	14.7	2.8	4.4	7.5	2

Table B4
Results of Qualitative Sampling at Site 29 (Reach 2) and Site 17 (Reach 3) at the Downriver End of Ice Box Slough and Moore's Bayou, Pearl River, August, 1995

Species	Site 17			Site 29
	RDB	LDB	Channel	Deep
Q. refulgens	16.10	69.23	46.51	9.74
P. purpuratus	12.68	3.59	1.97	23.67
O. reflexa	11.22	11.79	20.40	11.37
Q. apiculata	13.17	7.69	24.19	7.19
P. dombeyanus	19.51	0.51	0.00	12.53
G. rotunda	14.63	2.56	0.00	4.41
Q. quadrula	3.41	2.05	3.45	3.71
T. texasensis	1.46	0.00	0.99	4.18
L. claibornensis	0.49	0.00	0.00	4.41
V. lienosa	2.44	0.00	0.00	3.25
T. donaciformis	0.49	0.51	0.49	3.48
E. crassidens	2.44	0.00	0.49	2.32
T. verrucosa	0.00	1.54	0.00	2.09
L. fragilis	0.49	0.00	0.00	2.09
L. teres	1.46	0.51	0.49	0.93
F. cerina	0.00	0.00	0.49	1.16
U. declivis	0.00	0.00	0.00	0.93
L. ornata	0.00	0.00	0.00	0.70
T. truncata	0.00	0.00	0.00	0.70
U. imbecillis	0.00	0.00	0.00	0.46
F. ebena	0.00	0.00	0.49	0.00
P. alatus	0.00	0.00	0.00	0.23
P. grandis	0.00	0.00	0.00	0.23
O. unicolor	0.00	0.00	0.00	0.23
Total individuals	205	195	202	431
Total species	14	10	11	23
Total time	0	0	0	150
Total samples	12	12	13	14
Mussels/minute	0	0	0	2.9

Table B1
Results of Qualitative Sampling for Freshwater Mussels on the Pearl River Upriver of Wilson Slough, Through Wilson Slough to the Lateral Canal in the West Pearl River (Reaches 6 and 7)

	Site 5						Site 9			Site 11	
Species	Channel	RDB	LDB	Site 6	Site 7	Site 8	RDB	LDB	Site 10	RDB	LDB
O. reflexa	0.00	53.21	33.33	0.00	0.00	5.00	0.00	0.00	0.00	23.68	6.67
Q. apiculata	0.00	29.49	0.00	0.00	0.00	10.00	8.33	0.00	0.00	46.05	0.00
A. imbecillis	0.00	0.00	0.00	6.00	0.00	5.00	8.33	0.00	0.00	0.00	13.33
Q. refulgens	0.00	3.85	33.33	0.00	0.00	25.00	33.33	0.00	0.00	5.26	0.00
P. dombeyanus	0.00	3.53	0.00	0.00	0.00	0.00	8.33	0.00	0.00	2.63	0.00
Q. quadrula	0.00	2.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L. fragilis	0.00	0.00	33.33	0.00	0.00	5.00	8.33	0.00	0.00	0.00	6.67
E. crassidens	0.00	2.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. rotundata	0.00	1.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26	0.00
L. ornata	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
T. verrucosa	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L. teres	0.00	0.00	0.00	0.00	0.00	15.00	16.67	0.00	0.00	0.00	13.33
L. claibornensis	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	1.32	0.00
F. cerina	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F. ebena	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P. purpuratus	0.00	0.32	0.00	0.00	0.00	5.00	16.67	0.00	100.00	15.79	20.00
P. beadleanum	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total individuals	0	312	3	0	0	20	12	0	1	76	15
Total species	0	12	3	0	0	11	7	0	1	7	5
Total samples	2	2	2	1	1	1	1	1	1	1	2
Total search time	0	20	20	10.0	0.0	60.0	40.0	30.0	30.0	20.0	45.0
Mussels/minute	0.0	15.6	0.2	0	0	0.3	0.3	0	0	3.80	0.30

Note: Right descending bank = RDB; Left descending bank = LDB.

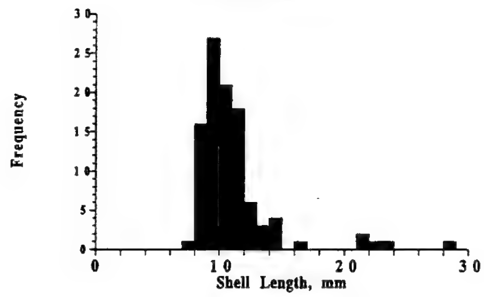
Table B6
Results of Qualitative Sampling for Freshwater Mussels in Holmes Bayou From Farr Slough to the West Pearl River

Species	Site 32		Site 33		Site 34	
	RDB	LDB	RDB	LDB	LDB	RDB
P. purpuratus	70.00	33.33	42.86	66.67	35.29	0.00
Q. refulgens	0.00	0.00	14.29	0.00	5.88	42.86
O. reflexa	0.00	0.00	17.14	0.00	23.53	14.29
L. teres	0.00	0.00	2.86	16.67	5.88	14.29
A. imbecillis	0.00	0.00	0.00	0.00	0.00	20.00
T. texasensis	10.00	66.67	2.86	0.00	11.76	0.00
L. fragilis	0.00	0.00	2.86	16.67	11.76	0.00
Q. quadrula	0.00	0.00	5.71	0.00	5.88	2.86
P. dombeyanus	10.00	0.00	5.71	0.00	0.00	0.00
G. rotundata	10.00	0.00	0.00	0.00	0.00	5.71
Q. apiculata	0.00	0.00	5.71	0.00	0.00	0.00
Total individuals	10	3	35	6	17	35
Total species	4	2	9	3	7	6
Total time	30	30	30	30	30	30
Total samples	1	1	1	1	1	1
Mussels/minute	0.33	0.10	1.17	0.20	0.57	1.17

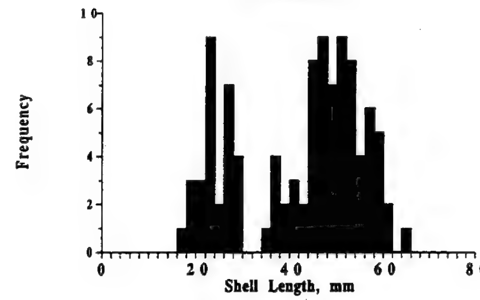
Appendix C
Size Demography of Dominant Mussel Populations in the Pearl River, 1995

Site 1, Reach 1
Pearl River
21 Aug 95

Corbicula fluminea



Obliquaria reflexa



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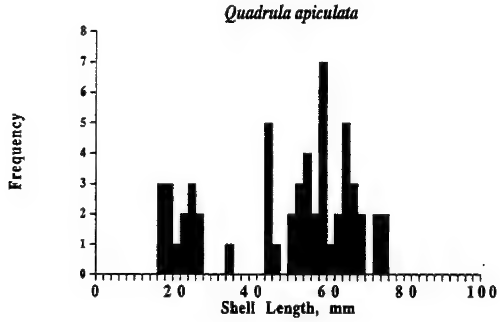

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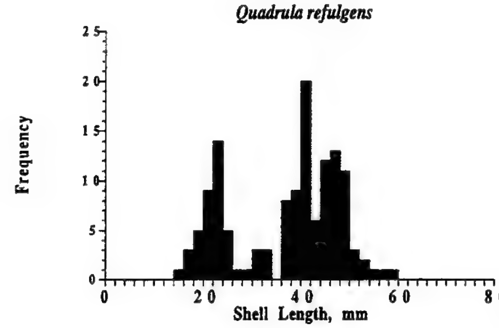

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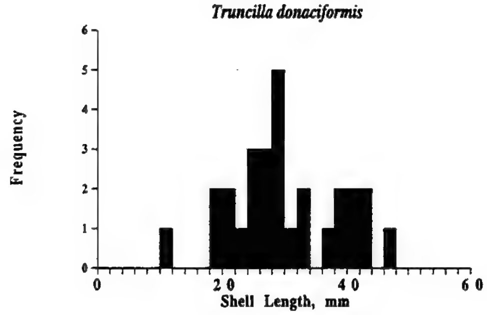
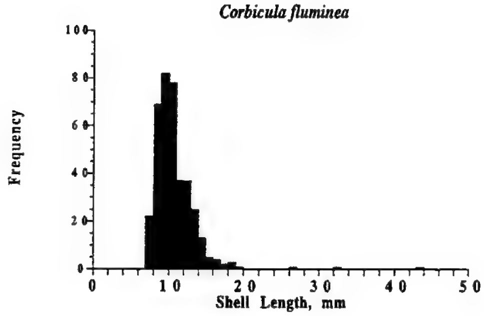
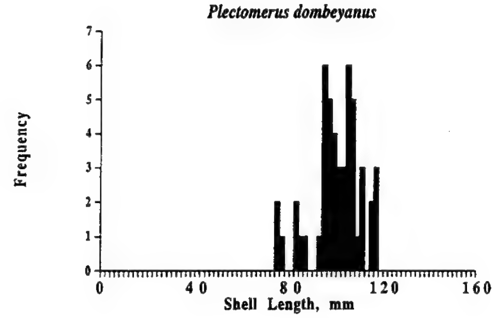


Site 3, Reach 1
Pearl River
22 Aug 95

Corbicula fluminea



Plectomerus dombeyanus



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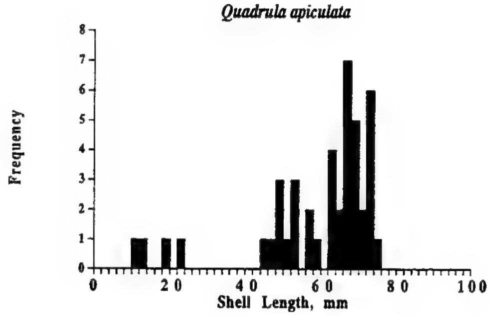
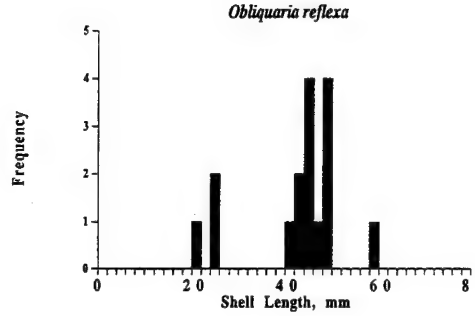
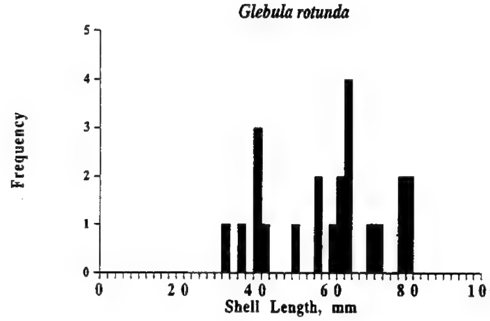


Obliquaria reflexa

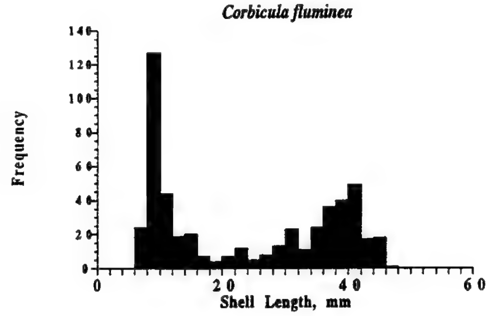


Glebula rotunda

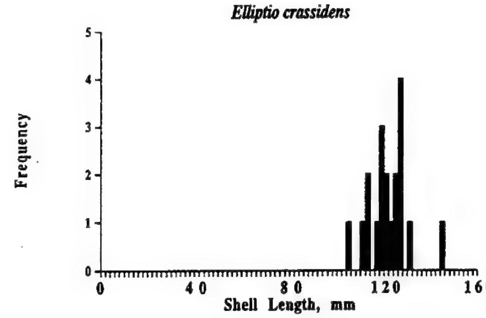


Site 3, Reach 1
Pearl River
22 Aug 95

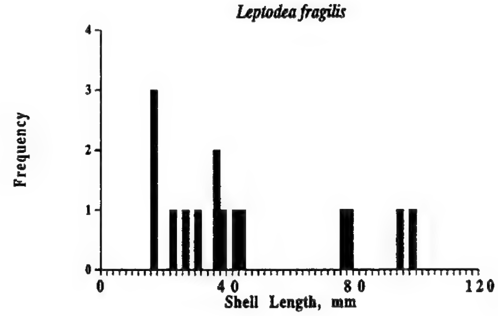
Corbicula fluminea



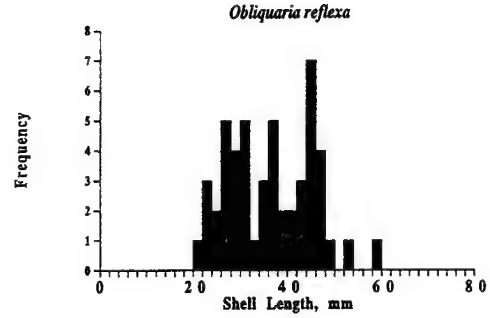
Elliptio crassidens



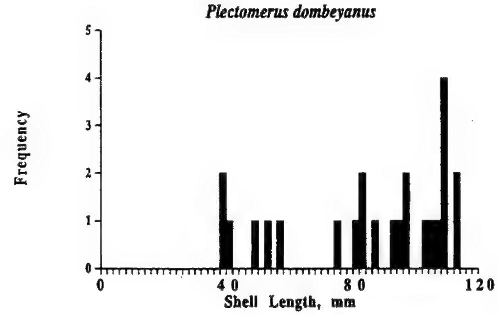
Leptodea fragilis



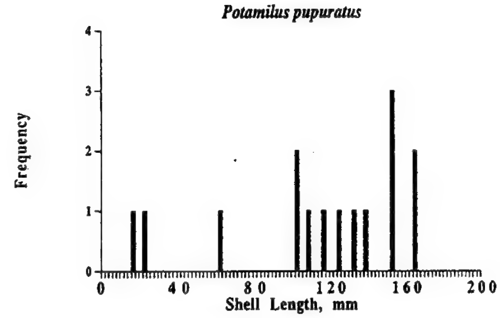
Obliquaria reflexa



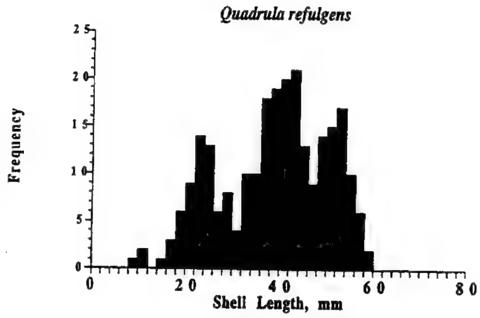
Plectomerus dombeyanus

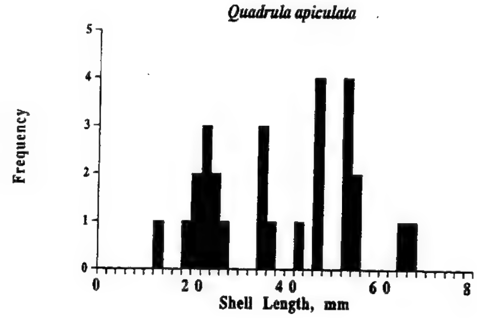


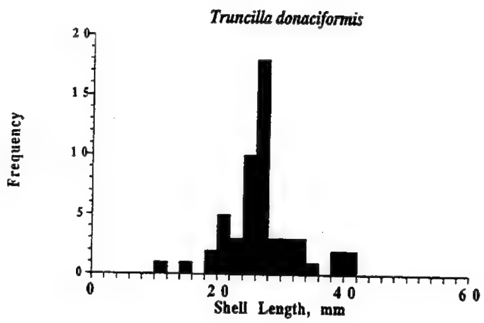
Potamilus pupuratus

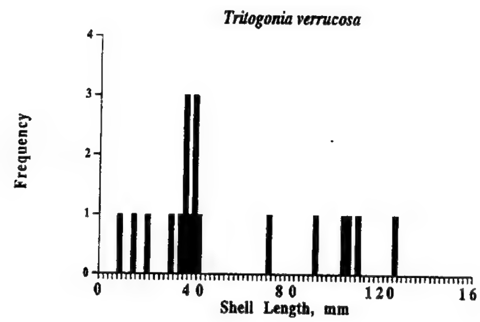


Site 3, Reach 1
Pearl River
22 Aug 95

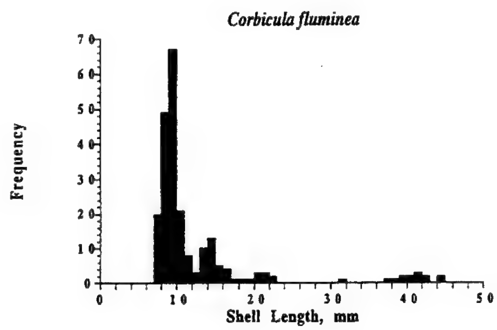


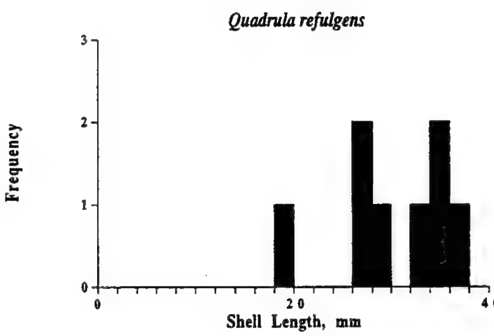






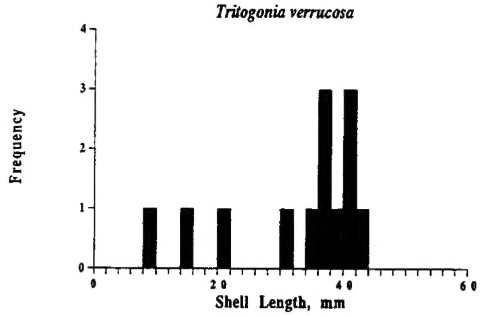
Site 29, Reach 2
Pearl River
27 Sep 95



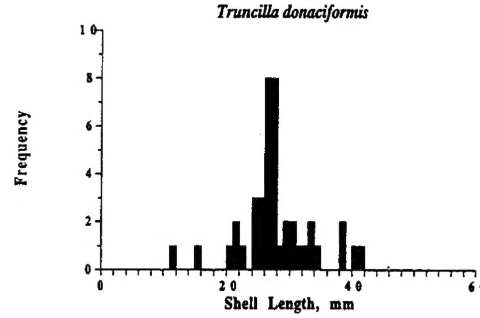


Site 17, Reach 3
Pearl River
24 Aug 95

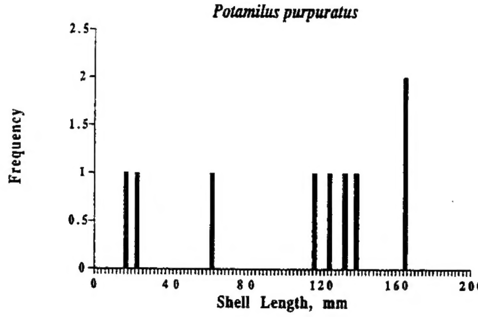
Tritogonia verrucosa



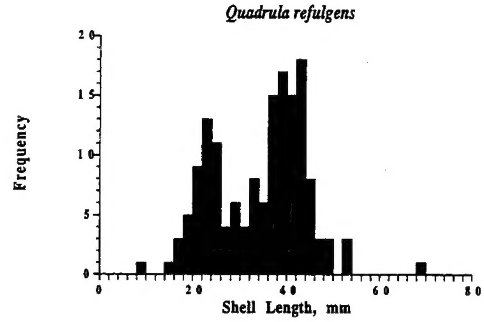
Truncilla donaciformis



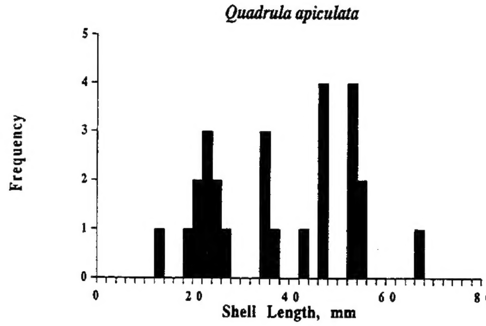
Potamilus purpuratus



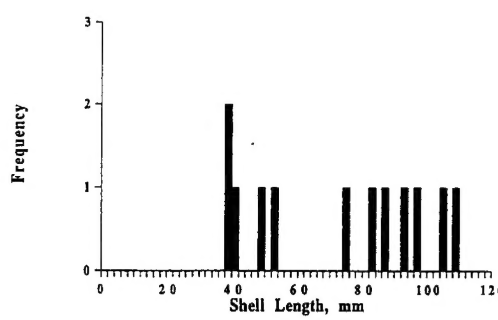
Quadrula refulgens



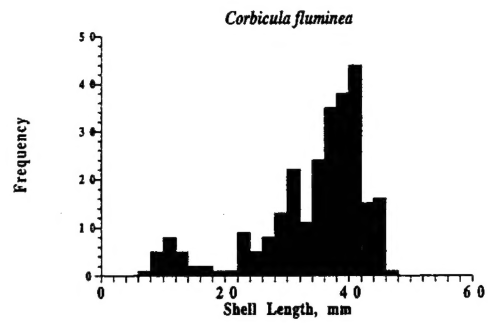
Quadrula apiculata

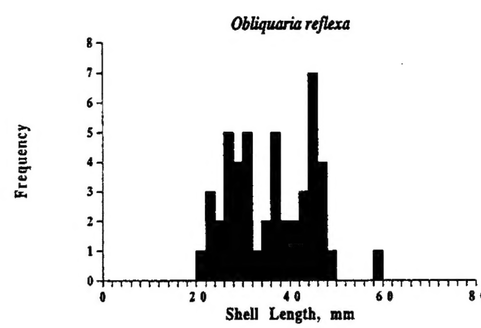


Plectomerus dombeyanus



Site 17, Reach 3
Pearl River
24 Sep 95





REPORT DOCUMENTATION PAGE

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Effects of Water Diversion on Freshwater Mussels in the Pearl River Near Walkiah Bluff, Mississippi and Louisiana, 1995

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13. ABSTRACT *(Maximum 200 words)*

A survey to assess community characteristics, density, population demography of dominant species, and the presence of endangered species of mussels (family: Unionidae) was conducted in the Pearl River near Picayune, MS, August-October 1995. Work was done for the U.S. Army Engineer District, Vicksburg, and results are being used to assess the environmental effects of three proposed water diversion alternatives designed to increase discharge and water levels in the Pearl River near Walkiah Bluff, Mississippi and Louisiana. An increase in water level in Reaches 1-4 of the Pearl River will be brought about by a decrease in discharge and water levels in Wilson Slough and areas downstream (Reaches 5-7). Low flow will be maintained in the river near Walkiah Bluff with a weir and closures in Reaches 1 and 2.

Reaches 1 and 2 contain a rich and diverse assemblage of mussels. Recruitment is high, and where suitable substratum exists, high-density populations of mussels were found. Shells of the threatened inflated heelsplitter were found in Reaches 6 and 7, although no live specimens were collected. This species was not found in Reaches 1-4.

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Three water diversion alternatives that differ on the percent water being shunted either into the Pearl River or Wilson Slough are being considered (30/70, 50/50, and 70/30 (Wilson Slough/Pearl River)). These alternatives will increase dependable low flow, in different degrees, in the Pearl River near Walkiah Bluff. Increasing water levels in the Pearl River will decrease the quantity of water and available aquatic habitat in Wilson Slough. As part of this project, a pilot channel will have to be dredged in Reaches 1 and 2 that will negatively affect freshwater mussels and their habitat.

Based upon measurements of water velocity and substratum types, Habitat Suitability Index (HSI) values for freshwater mussels were assigned to river reaches. For baseline conditions, HSI values were 1.0, 0.5, and 0.3 for Reaches 1 and 2, 3 and 4, and 5-7, respectively. In Reaches 1-4 without the project available, aquatic habitat (and its value) would decline to 0.0 by year 50. In Reaches 1 and 2 with the project, the Average Annualized Habitat Units (AAHU) for the 30/70, 50/50, and 70/30 alternatives were 31.4, 27.8, and 25.2. For Reaches 3 and 4, the AAHU were 158.7, 142.6, and 138.2. Higher AAHU result from shunting less water down Wilson Slough (and relatively more down the Pearl River, the 30/70 alternative). Habitat value in Reaches 5-7 increases by shunting a comparatively large percentage of water into the Pearl River; decreased flow will improve substratum stability in Wilson Slough and farther downriver. In Reaches 5-7, HSI values were 292.8, 267.3, and 253.5 for the 30/70, 50/50, and 70/30 alternatives, respectively.